REPORT RESUMES

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THE EFFECTS OF LISTENING TRAINING ON THE AUDITORY THRESHOLDS OF MENTALLY RETARDED CHILDREN.
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THE EFFECTS OF LISTENING TRAINING ON THE AUDITORY THRESHOLDS OF MENTALLY RETARDED CHILDREN WERE DETERMINED. THE EFFECTS OF LISTENING TRAINING AND ITS PROMISE FOR LOWERED THRESHOLDS WERE INVESTIGATED AND EVALUATED FROM CHANGES IN MAGNITUDE SCORES, DIRECTION OF THRESHOLD, INTELLIGENCE, AND BEHAVIORAL CHANGES IN COMMUNICATION ATTITUDES OR RATED BY INSTRUCTORS. FROM A TOTAL OF 400 CHILDREN, ONLY 199 WERE CONSIDERED CAPABLE OF RESPONDING TO HEARING TESTS. THOSE CHILDREN WHO DEMONSTRATED HEARING THRESHOLDS OF 30 DECIBELS OR GREATER AT TWO FREQUENCIES IN THE SPEECH RANGE NUMBERED 77, REPRESENTING 38.7 PERCENT INCIDENCE OF HEARING LOSS. ADDITIONAL TESTING ILLUSTRATED A REDUCTION OF THE INCIDENCE. THE EFFECTS OF THE PROGRAM UPON AUDITORY THRESHOLDS WERE OBSERVABLE, BUT NOT STATISTICALLY SIGNIFICANT. POSITIVE EFFECTS WERE ILLUSTRATED IN THE OTHER AREAS INVESTIGATED. IN ORDER TO NEGATE SOME OF THE BEHAVIORAL AND PHYSIOLOGICAL FACTORS WHICH INHIBIT RESPONSES TO AUDITORY STIMULI, IT WAS RECOMMENDED THAT HEARING TESTS BE REPEATED AT SELECTED INTERVALS, THAT A BATTERY OF TESTS BE GIVEN, AND THAT LISTENING TRAINING PRECEDE EXAMINATIONS. (JC)

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Morgantown, West Virginia

U.S. Office of Education
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Morgantown, West Virginia
September 20, 1961

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ABSTRACT

Most research literature indicates the high incidence of hearing losses among mentally retarded children. This fact must be considered in any evaluation of the potential of such subjects. This study is designed to evaluate the hearing ability of mentally retarded children by a selected battery of hearing tests repeated at three spaced intervals. This was done during a progressive listening training program of thirty units occurring within a period of seven months. The project thus was designed to add the elements of depth, time and training to the hearing evaluation of a retarded population.

The battery of hearing tests included (1) standard audiometric pure tone air conduction (2) ear-choice audiometry (3) play audiometry (4) standard bone conduction audiometry (5) GSR audiometry, and (6) a speech reception test. In addition, the subjects were given the short form Stanford-Binet and Peabody Picture Vocabulary Tests at the initiation and completion of the project. Relationships between variables and test results were ascertained. Judgments were made as to the responsiveness of the subjects to the training program and to GSR testing.

Sixty-five of 199, originally selected from a total population of 400, subjects met hearing loss and behavioral criteria. The mean CA of the selected subjects was 15 years, seven months, the MA mean 5-1, and the IQ 36.

The effect of repeated testing and training on the reduction of hearing threshold and changes in other measures was illustrated. The results of various criteria on incidence of loss were demonstrated for each test.

Repeated testing brought the incidence of hearing loss down considerably. However, while slight changes in the mean thresholds occurred, these were found to be non-significant, statistically, with the exception of GSR audiometry. Nevertheless, the direction of change was

found to be significantly positive in all tests with the exception of the Speech Reception Threshold test. Intelligence test scores showed observable and greater than anticipated change in magnitude of scores but these also were not statistically significant. They were significant only in the direction of change.

Significant relationships were found between initial speech reception thresholds and Peabody scores (one per cent level of confidence), speech reception thresholds and Stanford-Binet MA (five per cent), and chronological age and standard audiometry (five per cent level). A comparison of the means of GSR audiometry and standard audiometry at 1000 cps was non-significant, indicating face validity for these measures at that frequency. Communication interaction was judged as changing significantly in terms of direction.

On the basis of reliability of threshold results over all periods of testing, validity of responses and number of subjects able to be tested, the Speech Reception Threshold Test was suggested as the best choice for evaluating the hearing of retarded children. On the other hand, GSR audiometry was recommended only as a last resort. The addition of any of the three pure tone tests which differed primarily in responses to a speech reception test would make up a suitable battery for examining hearing thresholds of these children. It was suggested, that hearing testing be repeated at selected intervals using a battery of tests. Preceding the administration of these and other tests, such as intelligence tests, an auditory or listening training program was suggested to overcome to some degree some of the non-auditory variables that hamper assessment of hearing thresholds and other measurements of mentally retarded children. The same procedures of training and testing are suggested in attempting auditory evaluations of young children whose hearing is difficult to assess.

INTRODUCTION

Pure tone audiometric techniques are not always suitable for testing the hearing thresholds of young children. Traditional audiometrics are applicable to children down to ages six or seven, and not possible in cases of children with delayed, or no speech, according to Barr (6). Myklebust (65) states that comparable results with adults may be obtained only after the child has reached a chronological age of five, while a child with auditory disorders may not respond at an even higher age since such children cannot listen cooperatively and speak as normal children. Westlake (90) assigns variations in testing the hearing of three-and four-year olds to other factors than auditory acuity. Up to a certain point as age increases, hearing defects, as measured by audiometry, decrease. Past 20 years of age, for physiological reasons, raised audiometric thresholds occur (8) (79). The hearing mechanism does not mature, as Myklebust (66) points out, but the ability to listen does, as well as other integrative uses of sound.

The response to a meaningless auditory test tone is conditioned behavior that requires a subjective evaluation by the examinee. Variations in this stimulus-response situation emanate from sundry causes. Motivating devices are frequently employed to hold the subject's attention and focus it on meaningless tones which are barely perceptible. Thus, play audiometry in various guises are used. Other audiologists have attempted localization for auditory sensitivity (29), speech reception (61), and the use of so-called objective instruments such as psychogalvanic skin (electrodermal) response and electroencephalographic techniques. Even with these techniques Davis and Silverman (28) state that children who are uncertain and erratic in their responses to variations in pure tone testing are also erratic in objective test responses.

In order to be able to respond to a faint liminal sound wholly unrelated to his experience, the young child needs to have attained a certain level of intelligence and maturation. Such factors as behavioral and physiological aberrancies may inhibit the child's ability or desire to respond to audiometrics.

It can readily be assumed that a majority of the mentally retarded present problems in response to hearing testing and in typical test situations would demonstrate a high incidence of both real and fictitious hearing loss or a lack of response. Thus, hearing loss incidence for retarded populations has variously been reported as from two to ten times that of a normal population. Such a wide difference in estimates of hearing loss among the retarded results from many causes. Among these are (a) the use of different criteria as to the constitution of a hearing loss by various investigators, (b) sample differences such as level of intelligence, chronological age, etiology, et al., (c) techniques of testing, and (d) differences among the examiners. Seventeen per cent of 489 institutionalized subjects examined by Schlanger and Gottsleben (79) were designated as "nontestable." These subjects were usually below a mental age of five years, had personality disturbances of varying degrees and social quotients below 40. Four-fifths of the "non-testables" were either of organic or mongoloid etiology. Birch and Matthews (10) indicated that the reliability of the individual pure tone audiometer test was satisfactory between the mental ages of four years one month to five years in only two out of three cases. Above a mental age of seven years few difficulties were encountered. Part of the difficulty lies in assuming that mental retardation is an entity with a high relationship between it and auditory acuity.

In addition to peripheral losses other receptive disorders may be anticipated in a retarded population. These are based to a great extent on multi-causal factors such as pathology which might involve the ear and its neural pathway, and accompanying deviant behavior which may be a concomitant or the result of the pathology. The retarded are markedly deficient in auditory memory for sounds and sound discrimination, both of which are based in part on developing auditory acuity (76). Because of the learning and mental maturational deficit, the retarded subject may react occasionally or consistently confused, uncooperative, distractable, unresponsive to attempts to guage his auditory threshold. Those who do not understand what is expected of them and attempt to please the examiner by responding at random on cues from the examiner frequently add to the difficulties in attempting liminal sensory measurements.

The variations within the retarded populations, their manifold educational, psychological and sociological problems, and the difficulties encountered in locating large groups suitable for experimentation have not been conducive to experiments in depth. There is a paucity of information concerning their reception abilities and limitations. Diagnostic procedures and prognoses must take into account both real and functional losses. Most hearing examinations, however, in institution or special class environments rarely proceed beyond the administration of a pure tone audiometric air conduction sweep-frequency examination utilizing standard responses. As a rule, tests rarely are repeated or validated by the use of other audiometric measures, both direct and indirect. Lack of understanding of what is required of them may effect results in retarded groups, just as in the testing of young normal children. Many retarded subjects may feel more secure responding only to rather loud tones instead of the barely perceptible thresholds on which normal hearing criteria are based. Repetitions of tests, the use of varied tests, familiarity with examiners, and training in listening over a period of time could conceivably produce significantly different results from those obtained in an initial examination or even stabilize tentative findings. Conceiving mental retardation as a dynamic, rather than a static state of being, it is possible to remedy unfavorable attitudes affecting listening and, in turn, to obtain an improved response even though the retardation be immutable.

Problems encountered in testing the hearing of both young normal children and retarded subjects often consist of difficulty in understanding directions, recalling responses, and both internal and external distractions. The one-attempt screening audiometer test is neither a reliable nor a valid method of obtaining hearing thresholds of immature children. The mentally retarded frequently appear in these situations to have peripheral hearing losses which obscure their potential. On the other hand, children with delayed language development frequently give the impression of mental retardation when the root of the problem may be an undiscovered loss of hearing. Wood (92) investigating the causal factors of delayed speech and language development of 1, 200 children found 29 per cent who initially could have been classified as mentally retarded. Further intensive evaluations of 239 children indicated that 21 per cent had permanent mental retardation which was the primary causal factor precluding speech. She stresses the point that among other problems delaying communication, 10 per cent of the children previously suspected of mental retardation were found to have a hearing loss which had not been clearly detected during previous evaluation. The need for thorough examinations ruling out all facets delaying communication development are imperative. Errors in classification impose handicaps which hinder the potential development of the child.

If the retarded are considered as an experimental group in which something can be learned about the process of hearing, application may be found which would help in the testing of young children, enabling the examiners to minimize some of their errors and problems in such evaluations. Another possible employment is the emphasizing of a pre-test training program in listening which might enable the examiner to improve his measurements of the listening potential and auditory acuity of young normal and retarded children. In many instances, when the attention of an adult is directed to a sound that previously was at an unconscious level, he perceives it. It can be conjectured that the retarded might also be made cognizant of faint auditory stimuli once they have been trained to be aware of them. It is probable that many who appear to have hearing losses may hear sounds or words as well as normal children or adults. However, as a group, they demonstrate they are not willing or knowing enough to indicate reliably the presence of a faint tone, as in hearing testing, or attend to a series of sounds consistently. While the auditory apparatus of many mentally retarded subjects may have limits imposed on it by ear or other pathology, it can be assumed that with a normal peripheral hearing pathway, some improvement within psychological and physiological limits is possible.

REVIEW OF THE LITERATURE

This section will be divided into two divisions, one of which will be concerned with investigations pertaining to the testing of the hearing of retarded children, and the other will report references related to auditory training programs in advancing a rationale for a listening training program for a mentally retarded population.

Hearing Testing of the Mentally Retarded

There has been mounting interest in the past ten years in testing for hearing losses in retarded populations. Investigators first sttempted to determine the incidence of hearing loss of the mentally retarded through the use of standard pure tone audiometer techniques. Then adaptations of this method were tried as were special methods such as GSR (galvanic skin response) audiometric testing. Recently batteries of tests have been suggested and used in one investigation. Retarded populations have first been taken as a whole by some investigators; others divided them on the basis of chronological age and mental age in attempting to ascertain relationships between hearing loss incidence, ability to respond to hearing tests, and various attributes.

Beginning with Birch and Matthews (10) almost all of the investigators have indicated losses of hearing far in excess of that of normal populations. For the most part, these losses have ranged from a low of 12 per cent (80) of the retarded population to a high of 54.5 per cent (10). A recent study by Atkinson (3), which will be discussed later, gave significantly different results from any of those preceding his research. Table I summarizes various studies of the incidence of hearing loss in mentally retarded subjects offering further information by which they may be compared. It is important to realize that the populations are only roughly comparable since among other factors CAs, MAs, and IQs are not the same, etiology was not

TABLE 1

Summary of Studies from 1951-1961 Presenting Hearing Loss Data in Mentally Retarded Subjects

Investigators	No.	C.A.	M.A.	I.Q.	Technique Used	Hearing Loss Criteria	Hearing Loss Percentage
Birch and Matthews (1951)	247	10 to 19	median 7-0	median 49	Standard, Pure Tone Screening (512 - 8,192)	Ciocco-Palmer Categories	54.5 (32.7 severe)
Schlanger (1953a)	74	8 to 16 mean 12-1	mean 6-8	above 40	Standard (125 to 12,000)	Binaural Speech Loss A.M.A. 4-10 % or greater	30 (14 severe)
Schlanger (1953b)	62	6-11 to 16-7	3-7 to 10-11	39-77	Standard (125 to 12,000)	20 db or more in four frequencies in one or both ears	32
Johnson and Farrell (1954)	270	mean 13-2		mean 61	Standard (250 to 6,000)	20 db or greater at two or more frequencies in either ear	24
Foale and Patterson (1954)	100	10 to 19		mean 66	Standard (512 to 8,192)	Ciocco-Palmer Categories	33 (13 severe)
Bradley, Evans & Worthington (1955)	60	High Group (30) 7-11 to 13-6 mean 10-5	3-7 to 9-7 mean 7-2	54-79 mean 67	Alternate Ear (250 to 8,000) Standard	Greater than 20 db loss at two frequencies	43 30
		Middle Group (30) 7-8 to 12-4 mean 8-1	2-10 to 6-0 mean 4-9	34-50 mean 44	Alternate Ear Standard		47 33

TABLE I (continued)

Investigators	No.	Subjects C.A.	 M.A.	 I.Q.	Technique Used	Hearing Loss Criteria	Hearing Loss Percentage
Schlanger and Gottsleben (1956)	498	210 Subjects below 20, mean 13–11	total mean 7–10		Adaptations of pure tone audiometric testing (125 to 12,000)	20–30 db for two or more frequencies in one or both ears including frequencies outside the speech frequency range	12.4 slight 22.3 moderate 2.9 hard of hearing .5 deaf 10.5 non-testable
		288 Subjects above 20 mean 39–8					15.3 slight 31.7 moderate 8.3 hard of hearing 1.4 deaf 20.8 non-testable
Irwin, Hind and Aronson (1957)	20	9 to 38		23–72 median 50	GSR and Standard (500 - 1000 - 4000)	Not Given	Not Given
Kodman, Powers Phillip and Weller (1958)	208	Young Group (84 Subjects) 7 to 19 mean 15–5	mean 6–10	mean 53	Standard (250 to 8,000)	30 db or greater at one or more frequencies in either ear	19 9.1 non-testable
		Old Group (105 Subjects) 20 to 64 mean 38–9	mean 6–5	mean 48	Standard (250 to 8,000)	Same	24
Kodman, Fein and Mixson (1959)	31	7–5to21–4 mean 14–1	2–6to8–0 mean 4–4	25–64 mean 38	GSR and Speech Audiometry (500 to 2,000)	Not Given	Not Given

TABLE I (continued)

Investigators	No.	Subjects C.A.	M.A.	I.Q.	Technique Used	Hearing Loss Criteria	Hearing Loss Percentage	
Rittmanic (1959)	1220	6 to 80			Standard (250 to 8,000)	Two or more frequencies in one or both ears in excess of 15 db	40.5	
Siegenthaler and Kryzwicki (1959)	616	School Group (386 subjects) 14-46 mean 21-9		44-84 mean 52-5	Standard (250 to 4,000)	Average threshold for 500, 1,000 and 2,000 20 db or more in one ear	12	
		Non School Group (230 subjects) 22-47 mean 35		24-82 mean 51	Standard (250 to 4,000)	Same	24	
							Non-Inst.	Inst.
Atkinson (1960)	110	8 to 16		46-80	Standard	Two frequencies at 20 db or more for 500, 1,000 2,000, poorer ear	8.5	2.0
					Eye Puff		5.7	0.0
					Four-Choice Force Choice		1.9	21.5
					Bekesy (500 to 2,000)		86.0	64.9
Rigrodsky, Prunty and Glovsky (1961)	325	5-71	Not Given	Below 25 to Borderline	Standard (250 to 8,000)	20 db or greater for any two frequencies in one ear.	25	

considered as a variable, different techniques were utilized, and no standard criterion for defining losses was observed.

The first major study in the field was conducted by Birch and Matthews (10) who tested 247 institutionalized children using standard pure tone screening techniques. Their subjects ranged in CA from 10 to 19 years. The median MA was seven years and the median IQ, 49. Approximately 55 per cent of the subjects failed the sweepcheck at 15 db. Severe impairment was evidenced by 33 per cent. They felt that the large amount of hearing loss with mental defectives must be taken into consideration during diagnosis since a significantly large proportion of mentally retarded children were found with hearing losses. They concluded that pure tone audiometry is a suitable technique for testing mental defectives. Schlanger (76) tested 74 institutionalized children with an age range of 8 to 16 years and with IQs above 40. Computing hearing loss on the basis of a formula recommended by the American Medical Association, he found 30 per cent of the subjects had losses ranging from "slight" to "severe." Fourteen per cent of the subjects were in "moderately severe" and "severe" loss categories. Examining 62 non-institutionalized children attending special classes, Schlanger (77) found 32 per cent (20 subjects) had hearing losses based on the criterion that a lack of response at 20 db or more in four frequencies in one or both ears was a loss. Johnson and Farrell (52) also indicated losses comparable to the above with 24 per cent having hearing losses; this is approximately five times that of normal Massachusetts Public School children. In Scotland, Foale and Patterson (36) found 13 per cent of their population, roughly twice the incidence of loss in normal Scottish children, handicapped in life situations insofar as hearing is concerned. An additional 20 per cent had various slight losses.

Dividing their 60 subjects into two equal IQ groups of 30 to 50 and 50 to 79, Bradley, Evans, and Worthington (13) tested them using two response techniques, an alternate ear procedure and a standard test response. They found that 43 per cent of the high group and 47 per cent of the middle group had hearing losses in alternate ear responses, while with standard procedures they obtained a slightly lowered incidence of loss with 30 per cent of the high group and 33 per cent of their middle group demonstrating losses.

Schlanger and Gottsleben (79) examined 498 residents at The Training School at Vineland utilizing pure tone audiometric techniques adapted for mentally retarded subjects. They also accorded their subjects a longer training period preceding the testing of the subjects than is usually done. The examinees had also experienced previous hearing testing in routine yearly diagnostic re-examinations. The hearing loss criterion was a 20 to 30 db loss for two or more frequencies in one or both ears including frequencies outside the speech frequency range of 500-4000 cps. Levels of loss were also designated. In the total population, 14 per cent had slight losses at the extreme frequencies, 28 per cent had moderate losses, 6 per cent were hard of hearing and 1 per cent were deaf. Dividing the subjects on the basis of below and above 20 years of age, they found the younger population with a smaller incidence of loss than the older group. Thirty-eight per cent of the young group had various levels of hearing loss as compared to 56.7 per cent of the older group. Of the 210 younger subjects, 10.5 per cent were non-testable compared to 20.8 per cent of the older group. Kodman, et al. (58), using a criterion of 30 db or greater at one or more frequencies in either ear and dividing their subjects into young and old groups, obtained a hearing loss of 19 per cent in their young group, and 24 per cent in their old group. Nine per cent of the total were untestable by pure tone. Testing 1,220 subjects and using a lowered hearing loss criterion, Rittmanic (74) noted that 40.5 per cent of his group had significant hearing losses. Examining 616 females, divided into School and Non-

School subjects. Siegenthaler and Kryzwicki (80) indicated losses in 12 per cent of the former and 24 per cent of the latter group. Rigrodsky, et al. (73) found 25 per cent of their 325 Vineland Training School group with losses of 20 db or greater for any two frequencies between 250-8000 cps in one ear. They broke down the types of loss to indicate that 11 per cent of the subjects were classified as having a conductive loss, 44 per cent had a neural loss, and 45 per cent of the group had a mixed loss.

The varieties of results suggest the difficulties in comparing the data of various studies. Kodman (56) has indicated that if a standardized criterion of a 30 db or greater loss at one or more frequencies in either ear for defining losses were used, the incidence would be lowered to 15 to 20 per cent rather than the 25 or more per cent presently assumed. He discusses variables entering into the difficulties in testing. These consist of neurological pathology, psychogenic loss, inability to cooperate, malingering and test variability. Two other studies (10) (79) have indicated difficulties encountered in testing retarded children below the mental age of five years.

Several studies have suggested the use of more than one testing technique, perhaps a battery of tests. For example, Kodman, et al. (58) suggested the use of speech audiometry as an adjunct to GSR testing with retarded children below an MA of five. Schlanger and Gottsleben (79) also raised the question of the use of GSR with their "non-testable" subjects. Bradley, et al. (13) used two methods of pure tone testing. They were interested in determining whether or not a relationship existed between IQ and the time required to obtain threshold measurements. They concluded there was a relationship and that standard audiometric techniques took less time than their alternate ear techniques.

Atkinson (3) tried several test procedures which varied with regard to the response used to indicate hearing. Tests from which data are reported are (a) a standard pure tone audiometer test, (b) an eye-puff test, (c) a four-choice forced choice test, and (d) a Békésy test. A total of 110 mental retardates, half of whom were institutionalized, were matched with normal controls. CAs ranged from 8 to 16 years and IQs from 46 to 80. Atkinson stated that the incidence of hearing loss found among the mentally retarded did not differ from that of a normal group and also was comparable to the incidence of hearing loss for the population as a whole. One of the criteria upon which this was based was an average loss of 20 db for 500, 1000 and 2000 cps for the *better* ear. Based upon *poorer* ear findings, as generally used in studies reported above, the incidence of loss varied considerably from test to test, and gave slightly different results. It should also be noted that subjects on whom tests were attempted but who failed to give appropriate responses were not included in the analysis of hearing loss. It was felt by Atkinson that the standard hearing test procedure was the most effective in terms of being able to test the majority of the subjects from the group. No central tendencies were offered, but the children of this study with IQs from 46 to 80 may not have been comparable in IQ and MA with the major portion of subjects used in prior studies by other investigators. As the author explains, the discrepancies in results between his findings and the findings of others could be due to differences in testing methodology, motivational procedures, or sample differences. GSR testing was conducted on a few subjects but was not included in Atkinson's battery because of difficulty in establishing reliable or valid thresholds and because many children cried when given a mild shock.

Davis and Silverman (28) note that the very children who are poor in their responses to other techniques are the ones who are most likely to be erratic in GSR audiometric testing. A positive response means that the sound has stimulated the ear successfully and the impulses have reached at least the brain stem and have triggered off a response in the autonomic nervous system. On the other hand, failure to respond does not prove that there is a peripheral hearing loss.

Several investigators felt that GSR audiometry is not a suitable technique for children who show indications of brain damage, emotional disturbances, or manifest some degree of mental retardation. DiCarlo (29) questions the use of GSR audiometry for hyperactive children who are disabled communicatively. He prefers the use of localization techniques with infants and young children. Barr (6) feels that GSR audiometry is possible in many cases with retarded children who may have behavior problems. Although this method may fail to an appreciably greater extent than for psychically normal children, he states that children with development and behavior problems who respond to sound could be examined with play or GSR audiometry or both in about two-thirds of the cases of children between four and six years of age. It is his opinion that GSR audiometry is an unpleasant experience for a child. If another form of test is available, it should be tried first, with GSR audiometry reserved solely for cases in which play audiometry has failed or, because of the child's age, may be expected to fail. O'Neill, Oyer, and Hillis (70) concur in part in that in testing a small number of children who showed definite indications of brain damage, emotional disturbances or mental retardation, they found that in no case was GSR audiometry successful when play audiometry was unsuccessful. Charon and Goldstein (22) noted that it is more difficult to condition GSR in children whose auditory disorder may have reflected some defect of the central nervous system than to condition children whose hearing loss probably resulted from a defect of the cochlea or auditory nerve. In previous work, Goldstein, et al. (41) observed a correlation between low IQ and difficulty of conditioning. Other experiments discussed the difficulties and unreliability of GSR audiometric testing with retarded and brain-damaged children. They stated that results implied that GSR audiometry might prove to be no more successful than current techniques where these present methods are inadequate. Sortini (83) discussed cerebral palsied children who possibly were retarded. He found test-retest results over a five-year period in agreement only 47 per cent of the time. He stressed that it is preferable to establish a pattern of response rather than to accept the results of one test as conclusive. GSR audiometric testing is suggested as one of a battery of hearing tests in the total evaluation of the child whose brain is damaged.

An experiment by Collman (26) had as its primary object the investigation of the difference, if any, between GSRs of mentally retarded (IQ - 45-69), dull (70-89), normal (90-109) and bright (110-140) children. Using 827 subjects with CAs between 13 and 14 years he found that the mean GSRs of dull and normal groups to stimuli consisting of words, pictures and a sum were significantly better than those for either the extreme groups, the retarded and bright subjects. He reasoned that the retarded were not concerned about the experimental situation and therefore, their GSRs were at a minimum. Moss, Moss, and Tizard (64) also conducted an experiment using GSR audiometry with 24 institutionalized mentally defective subjects with CAs of six to eight and a median IQ of 37. These were selected subjects designated by their teachers as their most cooperative children. Records obtained in GSR testing were classified as good, fair, or poor. Only 13 of 48 records fell into the categories designated as good or fair. This led the authors to conclude that the unreliability of the test results was a function of the subjects' deficiency and not an artifact of the method or equipment. They concluded that GSR audiometry with mentally deficient children is of limited utility and concluded, as many of the above, that it seemed likely that most of these children who cannot be tested by standard pure tone methods probably cannot be tested by GSR methods.

On the other hand, Irwin, Hind, and Aronson (49) tested 20 institutionalized mentally defective individuals with suspected hearing losses and found that reasonably satisfactory GSR conditioning could be achieved in subjects of low IQ. They noted, however, that GSR audiometry is not as effective as standard audiometry as only half the cases had GSR thresholds within ten db of those obtained by standard audiometric methods. A quarter of the subjects were untestable because of inadequate conditioned responses or behavior problems. They implied that there is some doubt as to whether the unpleasantness or complications of GSR testing can be justified with subjects who can be tested in other ways. Success in use of GSR testing with mentally deficient institutionalized subjects was noted by Kodman, Fein and Mixson (57). They were able to test 28 out of 31 cases. There was no discussion of the selection of subjects except that they were described as mentally defective residents of state institutions. The need to work with children who cannot be tested by standard audiometer methods was discussed, but they did not indicate whether their subjects had failed to cooperate in such procedures. Correlating speech reception thresholds with GSR response at 500 cps and at 2000 cps, they found moderate correlations between GSR and speech audiometry of .74 at 500 cps and a correlation of .64 at 2000 cps which indicated at least face validity for GSR.

A review of the literature pertaining to hearing testing of the retarded has revealed that while the mentally retarded population exhibits a greater incidence of hearing loss than that found in normal populations, there is a wide range of incidence of loss from none to over 50 per cent. This can be understood when one realizes that mental retardation is not an entity and encompasses a large distribution of MAs and IQs. The criteria employed in most studies have been quite varied. The intellectual level of the subjects has also varied. Test procedures, while attempting to test the same behavioral-physiological process, have differed as a result of instrumentation and the examiners themselves. In most of the reports, the examiners did not attempt to ascertain the reliability of the responses by repeating the tests, nor did they offer a variety of tests to ascertain the validity of the respones of their subjects. It can be assumed that many of the results were colored by examiner judgments as to the response offered. Another phase of the testing in which little detail was offered was in the matter of training the retarded subjects to respond. It can be hypothesized that results might be different if tests were repeated at spaced intervals and the offering of several tests had been accomplished. The audiologist attempting to locate a hearing threshold may frequently be testing training rather than audition, so that an intensive training program might also have modified results.

Listening Programs

The purpose of this section of the investigation is to (a) report selected references related to auditory training or listening programs as they have been applied to different populations, and (b) discuss the modification of certain aspects of current programs so that they may be used in a program of listening training specifically adapted to mentally retarded subjects who do not respond satisfactorily to typical auditory testing techniques.

In order for a review of literature on listening training to be meaningful, it is necessary to make a distinction between "listening training" and "auditory training." Myklebust (64) infers that listening behavior is dependent on learning and maturation while general auditory behavior can be reflexive, involuntary behavior, and, in addition, may be dependent on learning and maturation. Listening is a term used frequently outside the professional areas of speech pathology and audiology. It denotes a complex skill, which occurs as a deliberate, concentrative act after certain auditory skills have matured. Listening as described by Barbara (4) suggests a dynamic relationship between a speaker and a hearer which is dependent to a considerable degree upon the integrity of the individual's organizational and linguistic abilities. Nichols

(68) says intelligence plays a definite role in the ability to listen, while Brown (16) states that listening is dependent on other factors in addition to intelligence and is a complex skill. Monroe (62) believes the listener's own knowledge and concentrative abilities are vital factors. Listening suggests comprehension of spoken thoughts, and all that is involved in such a complex activity. Ainsworth and High (1) imply that listening behavior and general auditory functioning are not the same in the statement:

> Although auditory abilities may be improved with practice, there is no reason to believe that such an improvement would increase listening comprehension.

The term "auditory training" is peculiar to the professional areas of speech pathology and audiology. Auditory functioning is typically described in terms of general acuity and specific abilities to localize sound, discriminate between sounds of all kinds, develop memory for sounds and sound patterns, analyze and synthesize sound sequences. The implication is that these skills are basic to speech and successful communication in receiving and conveying ideas, thoughts and concepts.

For the purpose of reviewing literature the term "auditory training" will be used since this is an investigation in the area of audiology primarily, the phase is used by most writers, and this terminology suggests inclusion of all auditory activities and not just the selected, highly complex skills of listening. Further, literature related to listening training has but few general applications to the mentally retarded, while auditory training investigations and procedures have considerable potential meaning and employment for the mentally retarded. Nevertheless, in the reporting of the research, the term "listening training program" will be utilized since the emphasis is on the improvement of listening attitudes in respect to the cooperation of the subjects in attending and responding to sound. It is understood that complex and integrated linguistic receptive skills are not being subsumed.

Auditory training as a rehabilitative measure has not been intensively investigated, although benefits from such training with the deaf are indicated. Silverman (82) was among the early investigators to demonstrate the efficacy of auditory training with the deaf. Ewing and Ewing (35) speak of a number of instances in which children were found in later tests after training to have more residual capacity then was first suspected. Others who have reported on the positive effects of auditory training include Morley (63), DiCarlo (30), Hudgins (48), Kelly (55) and Johnson (51). Wedenberg (89) demonstrated several cases who after three years of audiometric training showed improved pure tone reception. Auditory training produces positive results with speech defective as well as normal individuals. Bloom (12) and Trepel (86) report improvement in auditory memory span with training. Brong (14) states that auditory discrimination can be improved with training. Many clinical observations made by speech and hearing therapists support the findings of these studies. Concerning auditory training with the mentally retarded, Rittmanic (74) infers that such a procedure has potential. Inasmuch as Myklebust (66) feels that auditory abilities are dependent upon learning and maturation and Meyerson (61) observed that hearing for speech is dependent upon these same factors, it seems warranted to explore the effects of auditory training with the mentally retarded.

Before auditory training programs for normals could be used effectively with the mentally retarded, certain modifications would have to be made. Most auditory training programs for the deaf follow the broad basic pattern described by Carhart (19). This consists of (a) the development of awareness of sound, (b) the development of gross discriminations, (c) the development of broad discriminations among simple speech patterns, and (d) the development of finer discriminations for speech. The first three procedures appear to be the most appropriate for training the mentally retarded for the purposes of this investigation.

For the training of the retarded, modifications in present auditory training programs might be made in relation to (a) methods employed to evaluate and recommend individuals for auditory training, (b) the stimuli used in training, (c) methods of presenting the stimuli, (d) types of responses required of the subjects, (e) evaluation of the subject responses to auditory training, and (f) evaluation of the effectiveness of the auditory training program itself.

Regarding modifications in methods employed to evaluate and recommend individuals for auditory training, a statement by Silverman (81) is pertinent. In discussing guides for practice in auditory training he says:

> There is an approachable and potentially useful portion of the auditory area beyond the range of useful audiometry. Consequently, many children who have been termed "totally deaf" as a result of audiometric tests may be reached by auditory stimulation through properly designed apparatus. Formal training is essential . . . audiograms are not always indicative of a child's potential for appreciating speech.

With the mentally retarded there is reason to be concerned not only with the auditory area beyond the range of useful audiometry, but to be concerned with what is useful audiometry. Discrepancies in incidence of hearing loss reported among the mentally retarded as well as lack of uniformity in agreement on what constitutes a hearing loss may indicate a need for more useful audiometry. Formal training may make audiometry more useful. Spurious results from evaluative procedures may be due to the subject's lack of sophistication in the testing situation, a degree of which may be obtainable through auditory training prior to hearing assessment. Frisina (37) has commented:

> In testing mentally retarded youngsters it is sometimes necessary to raise the intensity of the pure tone a significant degree above normal threshold whereas with speech audiometry it is possible to demonstrate essentially normal hearing. The reverse of this situation is also sometimes true. This suggests that individuals with central nervous system involvements might have difficulties other than auditory acuity. Apparently additional loudness levels are necessary before reliable responses are made to pure tones. These factors suggest the importance of mental age, and the organismic integrity of an individual when attempting to evaluate hearing thresholds or potentialities

in the area of auditory training.

Considering the many negative factors involved in testing the hearing of the mentally retarded one can conclude that the audiogram may not always be indicative of their auditory acuity. Modifications in terms of types and numbers of tests employed and responses required are indicated in order to determine many retarded subjects' true threshold. The need to modify auditory stimuli for training purposes is also apparent. Concrete stimuli, unique and vivid enough to attract and hold attention, are needed. These stimuli must be understandable as well as motivating. Much of the marerial used in auditory training programs is beyond the intellectual abilities of the retarded. This is especially true of such advanced materials as fine speech discriminations and the development of memory for sound sequences. In this light, materials for listening practice should be at a lower developmental level. Certain auditory stimuli have been advocated for use with the mentally retarded. Barron (7) suggests musical sounds, musical games, animal sounds, bird calls, clapping and rhythm marches. Schlanger (78) mentions the use of toy band instruments and sound made by the self and others. Materials designed for the deaf may be adaptable for the retarded. Carhart (19) describes sound-producing objects such as cymbals, automobile horns, bells, drums, and low frequency whistles. Guilder and Hopkins (43), O'Neill and Oyer (69), Whitehurst (91), Johnson and Siegenthaler (50), among others, suggest useable materials.

Methods of presenting auditory stimuli vary considerably. Bird (11) advises the use of phonograph and tape recordings. Schlanger (78) has employed both live and recorded methods with the mentally retarded.

Another factor should be considered in relation to the method of presentation, although experimental evidence is not conclusive. O'Neill and Oyer (69) say:

The combined use of visual and auditory modalities in aural rehabilitation seems to be an established, if not necessary approach.

Silverman (81) notes that:

> Auditory training seems to be more effective through mutual reinforcement when combined with the use of other sensory systems.

Webb and Siegenthaler (88) found that merely to hear sounds was not as effective in teaching sounds to speech defectives. Guilder and Hopkins (43) and Whitehurst (91) believe that auditory training must make use of other modalities as well as hearing.

Responses expected of the mentally retarded must be geared to the neuromuscular and psychological capacities of the individual and the group. A meaningful behavioral unit employing the seeing, feeling, and describing, if possible, as well as the hearing of the sound and its source may be effective in establishing a meaningful stimulus-response pattern. Various responses have been used with both normal and mentally retarded children. Conditionings to sound have ranged from verbal to gestural indications, controlled activities to involuntary responses. All require the timing of some activity with a sound or a word. Startle responses (38), eyeblink responses (23) and ear-choice (27) have been used. Schlanger and Gottsleben (79) used finger raising, hand responses and pointing to either ear as well as responses to, "Do you hear it now?" Atkinson (3) in attempting to isolate procedures which would most accurately assess the hearing potential of mentally retarded children used a variety of tests to which responses differed. A finger raising response was used with standard audiometric procedures, an eyeblink indicated hearing in his eye-puff test, and a choice was offered between four temporal intervals and an associated light when a tone appeared in his four-choice forced choice test. The Békésy test, used by him, required the subject to push a button when a tone was on and release it when he did not hear it any longer. Barr (6) used various play audiometry techniques, such as Chinese

Checkers, piling blocks, moving toy animals, rings, et al. in his testing groups of normal and abnormal children. O'Neill, Oyer and Hillis (70) suggested selecting the type of testing procedure on the basis of observing the activities of the child in play. The child performed certain tasks in response to sensory stimuli, pushing response buttons, striking drums, piling blocks, ringing bells, etc. The age factor was important in selecting the type of conditioned response. Meyerson (61) had his young subjects point to pictures in response to a tape recorder output.

The above are usually considered subjective-oriented responses since they are voluntary actions, subject to the will of the examinee. The use of GSR audiometry, an objective technique, has been advocated, but several writers such as Barr (6), Davis and Silverman (28) and Goldstein (40) feel it is not the method of choice for various reasons. Electroencephalic audiometry has been used to measure electric potentials in response to sound, but Davis and Silverman (28) feel that it has not proven satisfactory and also is not generally available.

In evaluating the individual's responses to auditory training there are two factors to consider. The first is that present audiometric techniques may give a limited picture of progress. Goetzinger (39) alludes to this. Audiometry evaluates the type and degree of hearing acuity only. The second factor to consider is that general behavior as well as hearing behavior may change in response to auditory training.

Meyerson (61) referring to his clinical experience testing first grade children, states that it is sometimes possible to train a child who originally responded at 25 decibels above the adult zero reference level to respond to significantly lower intensities. Where training is not feasible, or where a child does not respond to training, it is impossible to determine if obtained thresholds which differ significantly from adult thresholds reflect impaired auditory acuity or the influence of non-auditory variables. Frisina (37) emphasizes that:

> It is important to realize that response to most tests of hearing and to auditory training in general is a subjective phenomenon, a stimulus-response situation. Relatively little is known about what actually occurs between the stimulus and the response. That is, the individual indicates when he hears and interprets in his own way what he hears. At present there is no direct measure of what he hears.

In this sense the audiogram does not show possible reduction in random activity, relationships with examiners, increased alertness to sound generally, or the ability to follow social permissions and prohibitions as they are conveyed through sound. It would seem justifiable to use subjective evaluations and descriptions of modifications in general behavior in evaluating response to auditory training. Although all forms and gradations of behavior may not be attributable to auditory or listening training and although subjective evaluations and descriptions do not lend themselves conveniently to statistical analysis, they may in certain instances corroborate objective test findings.

Finally, modifications need to be made in existing auditory training programs in the direction of built-in measurements which determine the efficiency of the program itself. O'Neill and Oyer (69) indicate one way to evaluate auditory training programs:

> The vital factor in any aural rehabilitation program is the degree of improvement that occurs because of such a program. To determine this, tests must be administered at the beginning of a therapy program, during the program, and at the termination of therapy.

In addition to test findings as indicators of the effectiveness of a program, observed test-taking behavior and subjective descriptions may offer an indication of the effectiveness of a listening training program.

STATEMENT OF THE PROBLEM

The present investigation was developed to examine more efficient methods in evaluating the hearing of mentally retarded subjects. It also will explore the possibilities inherent in repeated testing of a retarded population. There is a need to investigate various types of current auditory assessment techniques to ascertain which test or tests offer the most promise in hearing evaluations of sub-intellectual populations. There is also a need to know if training involving conditioning to tones and complex sounds will improve the mentally retarded subject's cooperativeness and attention during testing and aid in ascertaining whether a peripheral hearing loss exists. With concrete knowledge of a sense impairment in a person some modifications may be planned in meeting his future needs.

Aware among other conditions of (a) the variability of the incidence of hearing loss among the retarded reported by several investigators (b) the difficulties posed in testing this population (c) the constellation of factors resulting in a sympton complex broadly designated as mental retardation, and (d) the lack of previous investigations testing the hearing abilities of the retarded using depth and time in order to alleviate some of the foregoing problems, this research project was designed to:

A. Test the hearing of a selected group of mentally retarded subjects by using a battery of six hearing tests requiring different responses.
    1. Consider the test or tests that seem to offer the best means of obtaining reliable and valid auditory thresholds.
        a. Repeat the tests at designated intervals to determine the effects of repetition, familiarity and time.
    2. Compare various test responses.

        a. Voluntary (subjective) and involuntary (objective) tests.
        b. Pure tone audiometric responses with speech hearing responses.
    3. Investigate the effect of variables such as IQ, MA, and CA on selected hearing tests.

B. Offer a Listening Program following a developmental progression.

1. Determine on the basis of auditory measurements taken at indicated intervals whether such a program has any effect on auditory thresholds.
2. Ascertain the effects of such a program on the basis of administration of tests of mental abilities before and after the program.
3. Formulate judgements on communication interaction as effected by training in a listening program.

PROCEDURES

Subjects

The mentally retarded subjects used in this investigation were taken from the West Virginia Training School at St. Marys, West Virginia, and the special classes of the Monongalia County School System. It was anticipated at first that sufficient subjects could be selected from the institution population. It was found, however, that only 154 of the 355 institutionalized subjects would be suitable for pure tone screening audiometry. The remainder were either too young, severly impaired patients in a crib ward, or other low-grade incontinents. They were non-testable in any testing situation, including the measuring of responses to tone, noise and speech. In consultation with the administrative and medical staff of St. Marys, after observing the patients, determining their responsiveness to speech and reviewing case history data, it was felt that it would not be possible to condition these low-grade subjects to respond to hearing testing. Therefore, an additional 32 children from special classes of Monongalia County Schools were added for audiometric screening. At a later date when the program was underway, 13 additional institutionalized subjects were added who had been placed in the St. Marys Training School after the project was underway. This made a total of 199 out of 400 subjects who appeared to be capable of participating in audiometric screening.

The selection of subjects for further intensive testing and training was made on the basis of either one of two factors—the failure to respond in sweep-screening audiometry to two of the four frequencies (500 to 4,000 cps) used at 30 db or greater in either ear, or invalid responses to these pure tone stimuli, indicating that the subject was untestable or sufficiently inconsistent in his responses to raise a question in the examiner's mind concerning the validity of the subject's responses. There was a degree of freedom in this latter course for it entailed the subjective judgment of the Project Director, based on psychometry, observation of behavior and recommendation of the Staff of St. Marys Training School. In the few instances in which a choice of subjects was made under the latter factor, it was surmised that training procedures would enable the selected subjects to respond satisfactorily at their approximate thresholds. The lower limits of the intelligence quotient was 20, the mental age, approximately two years. A chronological age maximum of 24 years was tentatively established.

The screening audiometry method that was utilized consisted of a sweep-frequency test with the attenuator set at 20 db, following a loud sample tone of 1000 cps at 60 db. If the subjects did not respond at 20 db, the tone was then presented at 30 db. Instructions were brief and were accompanied by a demonstration of the response desired. This consisted of raising the hand when a tone, described as "a musical note," "boat whistle," "noise," or "horn" was heard. One ear at a time was tested. If the subject did not respond to this method, he was asked to point to the ear in which the sound was heard.

A total of 77 subjects, 67 from the institution and 10 non-institutionalized children met these criteria, and others noted above. A second sweep-frequency audiometric test using the same procedures was given one month later. This test was done by different examiners from those who offered the first test. This accomplished two purposes. It acted as a check on initial audiometric screening and determined what effect the repetition of a hearing test would have on selected subjects who previously had indicated hearing losses, inconsistent responses, or no response to sweep testing. Twelve of the 67 institutional subjects responded at normal thresholds on the second test, leaving 65 subjects, 55 institutionalized and ten non-institutionalized selected for the experiment.

Because of the nature of the institutionalized population insofar as withdrawals and enrollments are concerned, seven subjects who were selected for the program were withdrawn during the course of the investigation after having participated in initial testing. Five of 13 later admissions failed the screening audiometric examination and were added to the project and participated continuously throughout the program. The ten non-institutionalized subjects also participated continuously in the program. Six of the subjects who were selected were taking sedative drugs. In the breakdown of subjects into hearing or non-hearing groups, 90 of the 199 subjects tested, or 45.2 per cent, had normal responses to screening testing. Sixty-five of the 199 subjects, or 32.7 per cent of the group, had failed the hearing test under the criteria established. The remaining 44 consisted of subjects who were psychologically unstable, of too low intelligence, or could not or would not give any response, thereby leaving their auditory abilities open to question. These 44 subjects accounted for 22.1 per cent of the 199 subjects tested. Adding this group to the group with demonstrable hearing loss gave a maximum possible total of 109 subjects out of 199 or 54.8 per cent with hearing losses, or possible hearing losses.

Table 2 indicates the means and standard deviations of the CA, the Stanford-Binet MA and IQ and the Peabody Picture Vocabulary Test MA of the 65 subjects who formed the basis of the experiment at the initiation of the program. The mean CA was 15 years, seven months, with a standard deviation of four years, two months. The Stanford-Binet mental age of 56 subjects was five years, one month, with a standard deviation of two years; the mean Binet IQ was 36.4; the standard deviation was 13.4. The Peabody Picture Vocabulary Test was also given to this group. The mean MA was found to be four years, five months, with a standard deviation of two years, two months.

TABLE 2

Means and Standard Deviations of CAs,
Stanford-Binet MAs and IQs and PPVT
MAs of Subjects at Initial Testing.*

		Stanford-Binet		Stanford-Binet		PPVT	
CA	S.D.	MA	S.D.	IQ	S.D.	MA	S.D.
(N=65)		(N=56)		(N=56)		(N=64)	
15-7	4-2	5-1	2-0	36.4	13.4	4-5	2-2

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* Numbers may vary in total as five later admissions were not given Binet Tests and four subjects were unable to cooperate. One subject failed to cooperate in both tests.

It can readily be seen that the group was not typical of mental retardate populations since their MAs and IQs were much lower than in groups usually researched and also lower than almost all of the retarded groups reported in hearing surveys (See Table I). The subjects in this experiment could be loosely described as fitting the "trainable" category. While etiology was not explored, brain damage was readily discernible in many and the majority could be considered as demonstrating neuropsychiatric pathology.

Acoustic Instrumentation

The following electronic instruments were used in (a) screening, (b) ascertaining hearing thresholds, and (c) in the listening training program:

1. Two Beltone Audiometers, Model 15-A
2. Microtone ADC, Model 50E2
3. Microtone ADC, Model 53
4. Grason-Stadler psychogalvanometer, Model E664
5. Grason-Stadler Group Hearing Aid, Model 2608P

6. Grason-Stadler Speech Audiometer, Model 160B
7. Warren Auditory Training Unit, Model W-2-S
8. Wollensak Tape Recorder, Model T-1500

The audiometers were calibrated on the basis of results obtained from testing normal ears of college students. Ten students with normal hearing were examined using the four audiometers. Results at frequencies 500 – 4000 cps indicated that all of the audiometers were within allowable limits of five decibels of each other. Frequent checks using the above students and others during the three stages of testing as well as hearing checks by the examiners of their own ears at the time of examinations indicated that so far as was ascertainable there was no shift in intensity of any instrument which would significantly effect the results.

General Audiometric Procedures

Once the selection of subjects was made, the following battery of audiometric tests was administered at three spaced intervals by five qualified examiners:[1]

A. Pure tone audiometric tests

   1. Standard procedure air conduction (called standard audiometry)
   2. Standard procedure bone conduction (called bone conduction audiometry)
   3. Play audiometry
   4. Ear-choice audiometry

B. Speech reception threshold audiometry (SRT)

C. Psychogalvanic skin response audiometry (GSR)

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[1] In the initial testing five examiners were used in random order so that each subject had a possibility of that many different test administrators. With the exception of GSR audiometry and speech reception testing, which used two examiners, the remainder used one tester. In general, in each phase of the testing program, from three to five different examiners tested each subject. The mean number of examiners for all tests over the entire program was 3.6 different examiners per subject for individual tests.

The following intelligence tests were administered:

A. Revised Stanford-Binet

B. Peabody Picture Vocabulary Test

All of the audiometric testing of the institutionalized subjects was done in rooms located in the St. Marys Training School classroom building, and testing of the non-institutionalized group was done principally in two schools of Monongalia County--Evansdale and Seneca. The non-institutionalized subjects were also examined in part in the Speech and Hearing Clinic of West Virginia University. They were tested there by means of GSR audiometry since there was not adequate space in the two public schools in which special classes were quartered for the most efficient use of specialized equipment needed in this form of audiometric test.

The rooms in which testing occurred were not sound-proofed but were typical of testing areas generally used in public school audiometry. Newby (67) states that for purposes of ordinary hearing testing to differentiate between normal and impaired ears expensive, highly isolated rooms are not necessary. For this purpose public school rooms, unless the surroundings are unusually noisy, will suffice. He does indicate, however, that in order to obtain accurate threshold measurements, any follow-up testing of those discovered to have hearing losses should be performed under better testing conditions than are found in the average school.

Readings of room noise levels were taken with a Sound level meter, type 1551-A, manufactured by General Radio Company. Using the C scale of the meter, it was found that readings varied for the most part between 40 to 50 decibels. This was found to be adequate for hearing testing since the noise level was not sufficiently high to produce a masking effect. Any fluctuations in outside noise probably were reduced in intensity by the binaural earphones used in testing. With the exception of the bone conduction audiometric test, there was an appreciable reduction in amount of noise. At times some background noise leaked in but did not seem to disturb the subjects. In an experiment conducted by Schlanger (75), mentally retarded subjects whose etiology was diagnosed as brain-damaged were subjected to extraneous background stimuli while being offered a test of auditory word discrimination. He found the varying sound backgrounds did not effect the word discrimination choice of his subjects.

The pure tone audiometric tests determined thresholds at 500, 1000, 2000, and 4000 cps. In all instances the right ear was tested first in order to vary as little as possible the setting for each subject.

The complete battery of hearing tests was administered at the initial and final stages of the project, a time interval of seven months, while all tests with the exception of the GSR audiometric testing were also given midway in the training period, four months after the initial administration of tests. In the initial testing the subjects received the tests in the following groupings:

1. Standard air conduction and bone conduction audiometry
2. Play and ear-choice audiometry
3. Speech reception threshold audiometry
4. GSR audiometry

Each of the four groupings was administered on different days. Throughout the examinations, each subject was tested as far as possible by a different examiner from the one who had previously tested him. The order of presentation of tests grouped as above in initial testing was changed in both medial and final testing. Each child was offered instruction before each test as to the manner of response. At the conclusion of each paired or individual test, a reward in the form of chewing gum or candy was offered each subject. It was felt that this would motivate him to respond in a more cooperative fashion, and help to maintain interest for future examination.

The effect of this on scores was not determined.

Specific Audiometric Test Procedures

The specific audiometry tests given and procedures followed were:

A. Audiometric pure tone testing:

1. Standard air conduction

The subject was told to raise his hand the moment he heard a noise in the earphone which was touched by the examiner. A test tone of 1,000 cps was presented at an intensity of 50 db. The subject was then asked to raise his hand to indicate he heard. If he did not respond, the examiner raised his hand in conjunction with the tone, repeating directions, and also raising the intensity of the tone to a level which might bring forth the desired response. When a response was secured, the tone was decreased 10 db and continued to be lowered until threshold was reached. Intensity was then decreased to 10 db below this threshold and raised in 5 db steps until threshold was obtained again. Descending and ascending intensities were accomplished several times. The threshold was the point at which 50 per cent of the responses were correct. The order in terms of frequency was: 1000, 2000, 4000, returning to 1000 and 500 cps. The same procedure was followed for the left ear.

2. Standard bone conduction

The same procedure utilized in the above test was followed for bone conduction testing. No masking was used since it was felt that this would make the problem of testing too complex for the examinees. The bone oscillator was first placed on the subject's forehead to determine sound lateralization. The receiver was then placed on the mastoid. Neither ear was covered.

3. Play audiometry

Instead of responding by means of hand raising as in the above tests, the subject was told to pick up a ring and place it on a peg when a tone was heard by him. After a demonstration by the examiner, the subject was given several rings and told to place a ring on the peg when he heard a sound in the earphone and to continue to do so as long as he heard sound. He was permitted to practice this several times with a tone of loud intensity. As in the other tests, praise was extended to the subject when he responded correctly. When the supply of rings was exhausted, the process was reversed with the subject taking a ring or rings off each time, and for as long as, he heard a sound. The frequency order, intensity patterns and ear order were the same as in the above tests.

4. Ear-choice

The same order of frequencies and intensities was used for this test but sound was alternated from one earphone to another in no fixed pattern. This 'built-in lie-detector' enabled the examiners to test the validity of the subjects' responses. Varying patterns of alternating ears at each tone, or descending in intensity several times in one ear was made into a game wherein the subject tried to catch the "bird" or "bee" before it got away.

B. Speech reception testing:[1]

1. Three masonite panels, 15 by 5 inches, each with four selected Bryngleson-Glaspey (18) cards, a total of 12 different cards were presented individually to the subjects. Two examiners participated in this test. One operated the equipment (See Appendix A for equipment settings, calibration of test and spondee word list used) while the other examiner handled the subject, manipulated the panels of pictures, monitored the tape-recorded word list when the test begun. First, however, in an instruction period the subject was told the name of each picture. He then pointed to them as they were given with live voice by the examiner. This was done with each of the panels. When it was felt that the subject was sufficiently familiar with all the pictures and could place his finger on the correct picture named, earphones were placed on his head with instructions that, as he heard the name of the picture in one earphone, he would point to the picture whose name was heard. With panel one held in front of the subject, the tape recorder was started and the audiometer was set at 50 db. If the pictures were named correctly, twice in a row or three times out of six at the same intensity level, this was signalled to the second examiner who reduced the attenuator reading 10 db and continued this procedure until threshold was obtained. The examiners attempted readings 10 db below threshold and raised and lowered the level 5 db steps until threshold was achieved again. After completing the right ear, the tape on which the words were recorded was rewound and the same procedure was continued with the left ear.

C. Psychogalvanic skin response (GSR):

1. Using a Grason-Stadler psychogalvanometer, the following settings were employed in conditioning the subject to tone and shock.
   a. stimulus time - 1.5 seconds
   b. delayed time - 1.5 seconds
   c. conditioning time - .6 seconds
   d. conditioning level from .25 to 2.5 milliamps

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[1] The twelve picture cards with spondee names were selected by Dr. Vincent H. Knauf of Indiana University as part of a series of graduated auditory tasks designed to establish norms for audition in children. Findings, in collaboration with Drs. Claude S. Hayes and John V. Irwin of the University of Wisconsin, will be presented at the 1961 ASHA Convention in Chicago. The title of the study is "Developmental Norms for Certain Auditory Tasks."

Two examiners were used in this test, one operating the equipment, the other preparing the subject for the test and handling him during the test. After the subject was calibrated and the shock level threshold increased sufficiently so that good excursion of the writing stylus took place, three or more stimuli (tone) and conditionings (shock) were given beginning in the right ear at 1000 cps with an intensity level of 60 db. A minimum of 12 tones with and without accompanying shock were presented and interspered among the stimulus-condition pattern until good responses to tones were secured without shock. When the subjects appeared conditioned to tone and shock, tone in the right ear at 1000 cps and 50 db was presented. Three responses were accepted as indicating positive results. In some instances, two responses were accepted. In the more difficult subjects, one clear-cut response among several was occasionally accepted. The intensity of the tone was reduced in 20 db decrements until no response was obtained, then the examiners used 10 and 5 db shifts to attain threshold measurements. After obtaining a threshold at 1000 cps, the frequency was shifted to 4000 cps and the same procedure was followed. The time required for an examination ranged from a minimum of 40 minutes for subjects who could not be conditioned to 75 minutes for subjects who could be conditioned. Because of time limitations, difficulties in achieving conditioning and subject fatigue, only these two frequencies were used. The same procedures were followed in testing the left ear.

Intelligence Testing

Two intelligence tests were selected for administration to the chosen subjects at the time the battery of hearing tests was first administered and at the final auditory testing of the subjects. These were the Revised Stanford-Binet Tests of Intelligence and the Peabody Picture Vocabulary Test. Because of time limits and the difficulties in holding the attention of many of the subjects, it was felt that the abbreviated scale of the Stanford-Binet Test would suffice to obtain the information desired for this experiment. The Binet Test was given by a qualified examiner to 58 subjects at the initial and 54 at the final stages of testing. Seven subjects received the test only at the initiation of the program. The Peabody Picture Vocabulary Test (PPVT) does not require verbal replies nor does the tester need special training. Therefore, several of the staff were able to present this test to the subjects at approximately the same time that the Stanford-Binet was being administered.

Since the PPVT gives a quick measure of the individual's comprehension of the spoken word, thus providing some measure of receptive language, it was felt that it would be an appropriate instrument for mentally retarded subjects whose training was to be in audition. Comparisons could then be drawn between the two intelligence tests, levels of intelligence, progress in listening as indicated by advances in scores as well as other comparisons. Dunn (31) gives a reliability coefficient for trainable mentally retarded children of .87 and a validity coefficient, comparing the Revised Stanford-Binet with the PPVT, of .71 for trainable mentally retarded children. Sixty-four subjects were given this test before and after the offering of training in listening. Six were not included in the final PPVT testing as they had left the institution.

The Listening Program

Based in part on sources previously cited for general techniques and procedures, a listening (auditory) training program for mental retardates consisting of 30 progressively structured lessons was established. These lessons are outlined in Appendix 2. The objective(s) of each lesson are stated and the activities performed during each lesson are described.

Realizing that it would be erroneous to assume that all the subjects had the same psychological and physiological integrity and listening potential, the following modifications suggested in the literature on present auditory programs were made to meet the requirements of the majority of the subjects:

1. Since acceptance for the auditory training program was not based solely on a demonstrable hearing loss, and subjects who were included were initially untestable as well as those on whom valid testing results could not be obtained, although hearing loss was suspected, the training program included exercises in auditory test-taking. Such exercises were emphasized early in training in

Lessons 1 through 6 and intermittently in subsequent lessons.

2. Exercises in increasing awareness of sound and for teaching sound recognition, discrimination, and auditory memory ability for gross environmental sounds were offered. Required responses were usually gross motor activities commensurate with each subject's psychological and physiological capacities. At times the subjects were required to feel and see the sound source, and produce the sound stimuli as well as hear it. This was done to make sound meaningful and perhaps enhance the training process through integration and reinforcement of sensory channels. Lessons 7 through 12 were concerned with this activity.
3. Lessons 13 through 20, with the exception of Lessons 17 and 18, were concerned with localizing sound. Lessons 17 and 18 reviewed and reinforced previous lessons. This procedure was repeated in the final Lessons--27 through 30.
4. Lessons 21 and 22 were designed to teach memory for rhythms. A rhythm pattern was presented and the subject was asked to reproduce the pattern. Other rhythmic activities using music were stressed.
5. Lessons 23 through 26 were concerned with teaching responses to verbal commands and in teaching memory for verbal commands. Responses were in terms of physical activities and exercises.
6. A modification was made in the auditory training program at the 25th lesson. For fifteen minutes before each lesson period and thereafter the subjects listened as a group to recorded music via earphones. This period of time was free from instruction and required no structured responses. It was attempted in an effort to (a) decrease activity levels, (b) direct attention to the ear and perhaps increase

attentional abilities, (c) provide a pleasureable experience with sound for the subjects, and (d) make the use of earphones pleasureable.

Types of auditory stimuli such as pure tones, animal noises, sounds made by toy musical instruments and gross environmental sounds were used repeatedly throughout the lessons. These stimuli seemed most appropriate initially, were enjoyed by the subjects, and so were employed thereafter. The methods of presentation of the stimuli varied from live to recorded production, using tape recorders and phonographs of auditory training units, and from earphone presentation, either singly or binaurally, to free field stimulation using speakers within the amplification section of various electronic playback equipment. Whatever method or type of presentation was used, the emphasis was on an event pattern occurring at the ear, a stimulus presentation with a required response. As in the hearing testing, a choice of rewards was offered at the completion of the lesson. These consisted of some edible product.

The listening training program was administered to 53 subjects over a period of seven months, and to five subjects for three months. Lessons were given bi-weekly as far as possible and weekly the last seven weeks. Each subject received a minimum of twenty minutes of training either individually or in a group. In addition, the training received in auditory screenings and in the several formal auditory testing situations can be considered as an integral part of the training program. The number of instructors teaching the listening lessons varied from two to six. When more instructors were available, added experiences in conversational listening were offered the subjects while they were awaiting their turn to receive the lesson. Recorded music was also offered as explained in paragraph six above.

It must be realized that with lower grade retardates, formal or informal audiometric testing may not reveal the complete effects of the auditory training program. In order to provide additional information, the teachers kept a log of behavior and progress, if any, observed in the many contacts taking place with the subjects. These descriptive accounts are often found to be of more clinical value than the coldly impersonal statistic. At the initiation and end of training a subjective "communication interaction" score was given each subject by project personnel. These scores were based on a five-point scale of zero (no oral communication) to five (normal communication interaction).

Another subjective measurement used was that made by the examiners of subject reaction to GSR audiometric testing. In a sense it was somewhat analogous to the above in that it evaluated subject behavior during testing, response to shock, ease of conditioning and general activity level. This was not the same type of evaluation as made by Moss, Moss and Tizard (64) who used a similar three-point scale consisted of 1 for poor, 2-fair, and 3-good.

Analysis of Data

Due to the poor responsiveness initially of the total population of the institution, any attempt to discuss the percentage of incidence of loss of hearing would be based on a skewed curve. It was felt that the group, including non-institutionalized subjects, that was screened might be used for any discussion concerning the amount of subjects with hearing loss under varying criteria.

The subjects selected for the investigation were compared on the basis of hearing thresholds at three intervals of training in listening, which encompassed a seven month period. These intervals are interval 1, before training; interval 2, during or mid-point in training; and interval 3, the completion of training.

There were four separate groups of subjects designated in Appendix 3 as:

1. A1 to A43, institutionalized subjects, who received all tests and participated in the entire listening training program.
2. B1 to B10, special class subjects, who also participated in all tests and the program.

3. N1 to N5, institutionalized subjects, who were added after the initial testing and program were underway, joining the program at the time the midway point was reached. Results were included in statistical analysis for first and second intervals.

4. O1 to O7, institutionalized subjects, who left the institution after initial testing and after selection for the listening training program. Results included in some initial analyses.

Where it was possible to include the above groups in statistical analysis, this was done. In some cases, subjects did not respond to testing and were not included in the statistical computations. Note is made of this in many of the tables. For example, Subject B10 did not respond to any of the tests at the three intervals of testing; B6 did not respond in initial testing but could be tested in intervals 2 and 3 by two hearing tests.

Groups A and B were given Stanford-Binet and Peabody Picture Vocabulary Tests at the first and third intervals, Group O received them at initial testing only, and Group N subjects received the PPVT at the initiation and completion of their short-term program.

A comparison of monaural hearing thresholds for both ears at the three intervals of training was done by computing the average audiometric thresholds in decibels of four pure tone tests using frequencies 500, 1000, 2000 and 4000 cps and GSR audiometry mean thresholds using 1000 and 4000 cps. Speech reception thresholds obtained at three intervals were also compared with each other.

Since the mean is not always applicable as a standard of comparison, linear regression techniques were utilized to compare the average hearing loss on intervals of time, or a regression coefficient of Y on X. The interval estimate of the slope, or β, was then used to test the null hypothesis that the hearing thresholds did not change from one test interval to another.

Initial and final mean thresholds of each of the individual tests was compared, counting the number of individuals not meeting the following criteria in their poorer ear:

1. Two of four frequencies at 20 db or greater
2. Average of 20 db or greater for four frequencies
3. Two or more frequencies at 30 db or greater
4. An average of 30 db or greater for four frequencies
5. Number of non-testable subjects

Product-moment correlations were computed between standard pure tone and speech reception audiometry to determine whether a significant relationship existed. This was done for both initial and final testing, using right ear thresholds.

In order to test whether a significant difference existed between GSR and standard audiometry, a t test of the significance of the difference between the means was utilized comparing results for the best ear at 1000 cps at both initial and final testing.

Other audiometric analyses considered the types of losses on the basis of a comparison of standard and bone conduction audiometry, and the levels of severity of loss.

The mean mental ages obtained from Stanford-Binet testing were compared using initial and final interval test scores. The statistical measure used was the t test of the significance of the difference between the means. This was also done with the PPVT mental age. A further use of the PPVT MA was to determine if a relationship existed between the MA and speech reception thresholds for the right ear at initial and final testing. Relationships were also determined between selected audiometric tests and variables CA, MA and IQ.

Utilizing much of the information derived from the above, some inferences were made indicating what audiometric test or tests might give the lowest thresholds and also the most consistent thresholds in testing trainable or lower retarded children. In order to determine whether there was a significant direction of change in hearing thresholds, mental ages and communication interaction, levels of confidence were computed using the McNemar Test for Significance of Changes.

Realizing that audiometric thresholds might not offer a valid estimate of any change in behavioral interaction brought about by a program of training in listening, the subjects were rated by instructors who had the most number of contacts with them. In addition, sample illustrations were utilized describing behavior since statistics based on a narrowly selected sample, such as used in this study, cannot often lead to correct inferences about a varied mentally retarded population. The individual subject often is obscured by generalities based on statistics. The individual is the focal point in diagnosis. When one comes down to it, the purpose of an investigation of this type is to improve individual diagnostic procedures by indicating specific needs such as (a) more reliable and valid hearing testing in examining a retarded subject; (b) alerting others examining him by making them aware of the nature of his auditory handicap, and (c) developing improved individual programming as a result of a more clear-cut prognosis.

RESULTS AND DISCUSSION

Incidence of Loss in Audiometric Screening

Based on initial screening, it is extremely difficult to arrive at the per cent of incidence of hearing loss among the mentally retarded subjects in this study. The total population included 368 institutionalized subjects and 32 special class, non-institutional subjects. Only 167 of the 368 institutionalized subjects could possibly be tested, as explained under Procedures. In initial audiometric screening, beginning with an intensity level of 20 db, 67 of 167 institutionalized subjects and 10 of 32 non-institutional subjects failed to pass this level. These subjects also were unable to hear or respond to increased intensities of 30 db at two or more frequencies in either ear. A criterion of 30 db at two frequencies is much greater than any utilized in the various studies listed in Table I. It was also pointed out that the subjects of this study with mental ages of 5 years, one month ± 2-0 were lower in MA than in all but one of the studies (13) listed in which an incidence of loss is reported. Nevertheless, 77 of 199 subjects failed the audiometric screening, an incidence of hearing loss of 38.7 per cent. A second screening found 12 of the subjects who previously were suspected of hearing losses with responses of 30 db or 40 db achieving good responses at 20 db. Seven, who were not testable but seemed to have losses the first time they were tested, responded but at 30 db or higher to several frequencies. The final total of subjects with losses under the criteria established was 65 (32.7 per cent of 199). It must be noted, however, that 44 of the 199 subjects had performances in testing that left some doubt as to their abilities to respond. They were either too low intellectually or too seriously disturbed to include in the program. Thus, if the total of subjects, now reduced to 155, is divided by 65 subjects with real or suspected loss, the incidence of loss is approximately 42 per cent. It can be seen what difficulties are inherent in attempting to ascertain the per cent of loss of hearing of certain levels of mentally retarded populations. If the institution is one which retains low-grade subjects and paroles those who can perform some work in keeping with their capacity, measurements, particularly in hearing, will be difficult to obtain and open to question. There is no doubt, however, that the incidence of loss, whether the statistic of 32.7 or 42 per cent be accepted, is in keeping with most studies and presumably would have been much higher if (a) a criterion lower than 30 db at two frequencies had been used, or (b) the total population of 400 with its large non-testable group had undergone testing and the non-testables had been listed as having hearing losses.

Audiometric Results at Three Intervals of Testing

The mean audiometric thresholds of all subjects for the various hearing tests given at three intervals are shown in Table 3. Both right and left ear results are indicated. The standard air conduction, ear-choice and play audiometry tests demonstrate slight decrements in threshold at all intervals for both ears. These three tests compared to each other gave approximately the same results at each interval of testing with no difference at any interval greater than two decibels except at interval 2, right ear, between standard and play audiometry where the difference of the mean is 2.3 db. The decrements from interval 1 to interval 3 are not great enough to indicate a real difference. From interval 1 to interval 3 the largest difference between the means was that of standard audiometry, left ear, with 5.6 db. The least difference was ear-choice audiometry, right ear, with a difference of 2 db. A comparison of ears in each test at each interval showed no ear with mean differences greater than two decibels except in the case of standard audiometry, left ear, at interval 2 in which a diminution of 5.5 db is seen. Without subjecting this data to detailed statistical analysis, it can be seen that there is a consistency between

TABLE 3

Mean Audiometric Thresholds for All Hearing Tests
at All Intervals, Both Ears

		Interval 1			Interval 2			Interval 3		
Ear	Test	N*	$\overline{X}$	S.D.	N	$\overline{X}$	S.D.	N	$\overline{X}$	S.D.
Right	Standard	54	25.9	2.3	53	25.5	2.5	47	22.6	2.4
	Ear-Choice	54	25.2	2.4	53	23.9	2.5	49	23.2	2.6
	Play	55	25.6	2.1	52	23.2	2.6	49	21.6	2.5
	Bone Conduction	52	20.7	1.7	48	17.8	1.6	45	16.9	1.2
	SRT	57	14.7	2.3	57	15.1	2.2	51	15.9	2.7
	GSR	41	30.9	3.0	Test Not Given			37	17.1	2.5
Left	Standard	54	26.6	2.5	52	21.1	2.2	47	21.0	2.2
	Ear-Choice	54	25.3	2.3	53	22.5	2.5	49	20.8	2.5
	Play	55	26.2	2.1	52	22.6	2.6	49	21.0	2.5
	Bone Conduction	52	22.2	1.7	48	17.6	1.2	45	17.5	1.1
	SRT	57	14.0	2.4	57	12.4	2.1	51	12.7	2.3
	GSR	39	34.5	3.5	Test Not Given			34	18.8	3.1

* The number given tests at various intervals may differ as some subjects could not be tested or were not available. GSR audiometry, which was administered only at Intervals 1 and 3, was not given to five subjects who entered the training program at the mid-point in training. The group, N, is included in Intervals 1 and 2.

these tests in terms of similar threshold results, a slight diminution in intra-test thresholds and similar results for both right and left ears.

Bone conduction audiometry for all intervals follows the above trend with a slight drop in intra-test thresholds at each interval; intervals 1 and 3, right ear, 3.8 db, left ear, 4.7. As can be expected, the BC average is lower at each interval than the AC averages. Various middle ear impairments anticipated in some of the children who are prone to respiratory infections would account for some of the decrements in BC thresholds. The closeness of the results probably can be accounted for by three factors--the possibility of neural loss, the responsiveness of the subjects only to loud sounds of which they are sure, and the fact that, whereas binaural earphones were used in air conduction testing, the ears were left uncovered in bone conduction testing.

The speech reception threshold results were the lowest of all the tests. These thresholds also dropped least of any of the tests during the three intervals of testing. As a matter of fact, the right ear mean threshold increased 1.2 db from Interval 1 to Interval 3. The left ear showed a diminution of 1.3 db over the same period of time. In terms of lowest threshold, consistency of responses for both ears and over the period of time of this research, the speech reception test appears to give the best results. At each interval there was a slight increase in subjects able to be tested by SRT as compared to play, standard and ear-choice audiometry. For example, comparing standard and speech audiometry, in the first interval, 54 of 65 subjects (83 per cent) responded to standard audiometry, while 57 of 62 (92 per cent) subjects responded to speech audiometry. Fifty-three of 58 subjects (92 per cent) responded at the second interval to standard audiometry, while 57 of 58 (98 per cent) were tested by speech audiometry. In the third interval speech audiometry again had the most respondents with 51 of 53 (96 per cent) as compared to 47 of 53 (89 per cent) tested by standard audiometry. Three subjects who did not respond to any of the other hearing tests were able to respond to SRT methods with two responding normally and one with a slight loss.

At this point it must be noted that, whereas pure tone audiometry attempts to ascertain the threshold of detectability, the speech reception testing is concerned with understandability. The subjects had specific pictures which they recognized, and a gesture, that of pointing to a picture, which was familiar and part of their symbol usage. In terms of subject behavior ob-

2

served during the testing, most of the children were definite and much surer in their responses to the SRT test as compared to the various responses required of standard (hand-raising), play (rings on a peg) and ear-choice (touch earphone) audiometry. It can be suggested that speech audiometry may approach more closely to these subjects' auditory thresholds than the pure tone tests mentioned above.

GSR audiometry, offered only at Intervals 1 and 3, demonstrated the greatest decrement of any of the audiometric tests used. There was a diminution in mean thresholds of 13.8 db, from 30.0 to 17.1 db, in the right ear and 15.7 db, from 34.5 to 18.8 db in the left ear. This was by far the greatest difference between mean thresholds recorded by any of the other five tests. On the other hand, the number responding to the GSR testing is much lower than in the other tests. For example, in Interval 1, right ear, 41 of 58 subjects to whom the test was administered were able to be examined by this method. At the third interval, right ear, 37 of 53 subjects responded adequately to the test. At both intervals, approximately 71 per cent of the subjects could be tested.

It is interesting to note that the per cent of the subjects responding was slightly less for the left ear in the GSR technique. This probably could be accounted for by the fact that the right ear was tested first and two of the subjects at the first interval and three at the second interval may have been too fatigued or unwilling to carry on.

In all of the testing, the number of the respondents was less for the GSR method. As an example, 92 per cent of the subjects responded to SRT at the first interval and 96 per cent at the second interval compared to 71 per cent at both intervals for GSR.

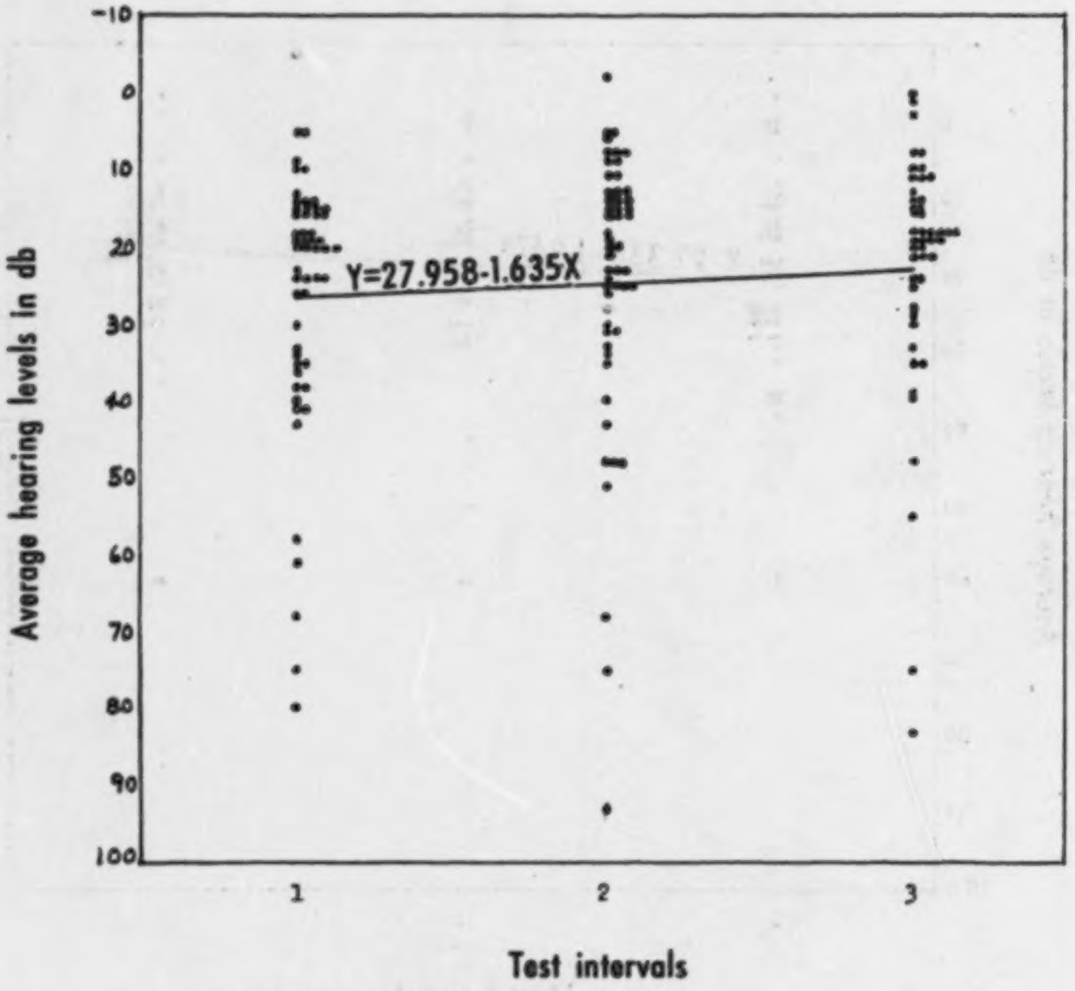

FIGURE 1. Sample regression of Standard Audiometry average thresholds (right ear) on time.

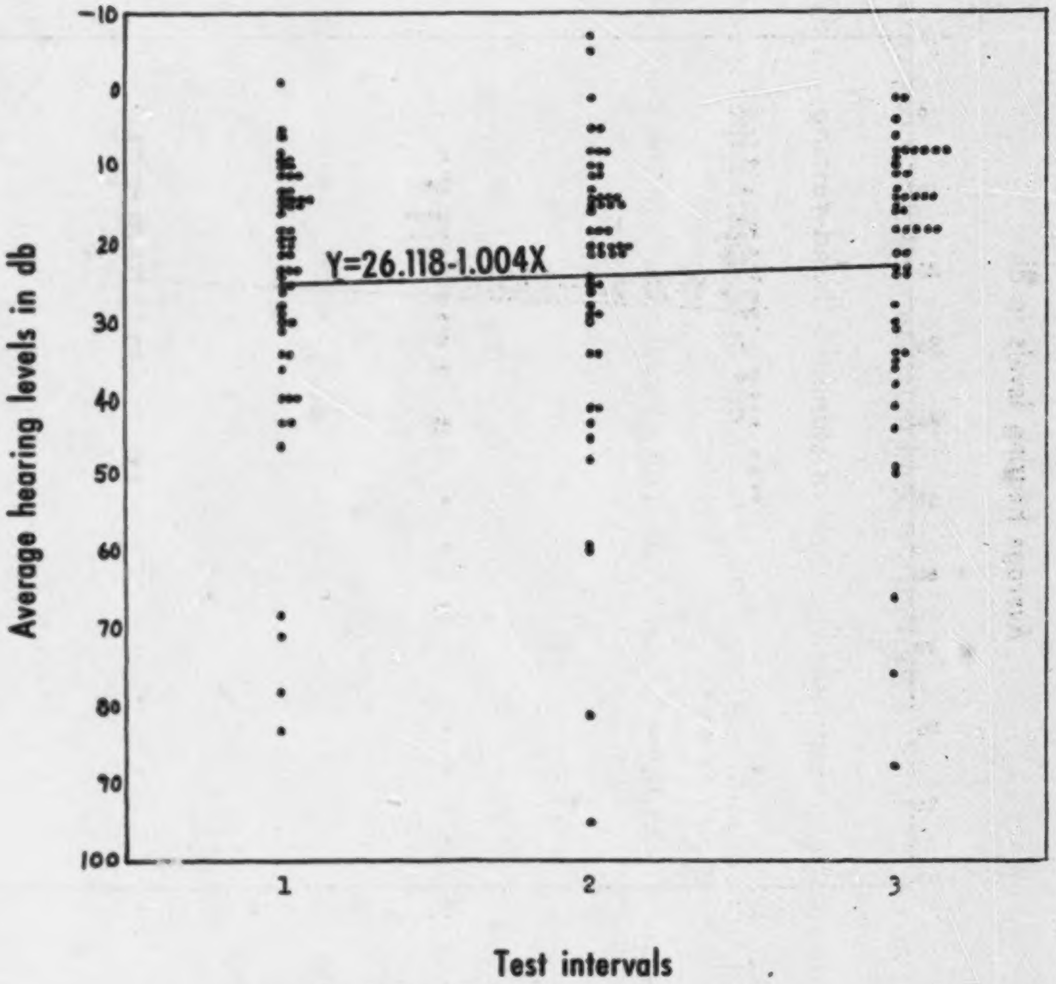

FIGURE 2. Sample regression of Ear-Choice Audiometry average thresholds (right ear) on time.

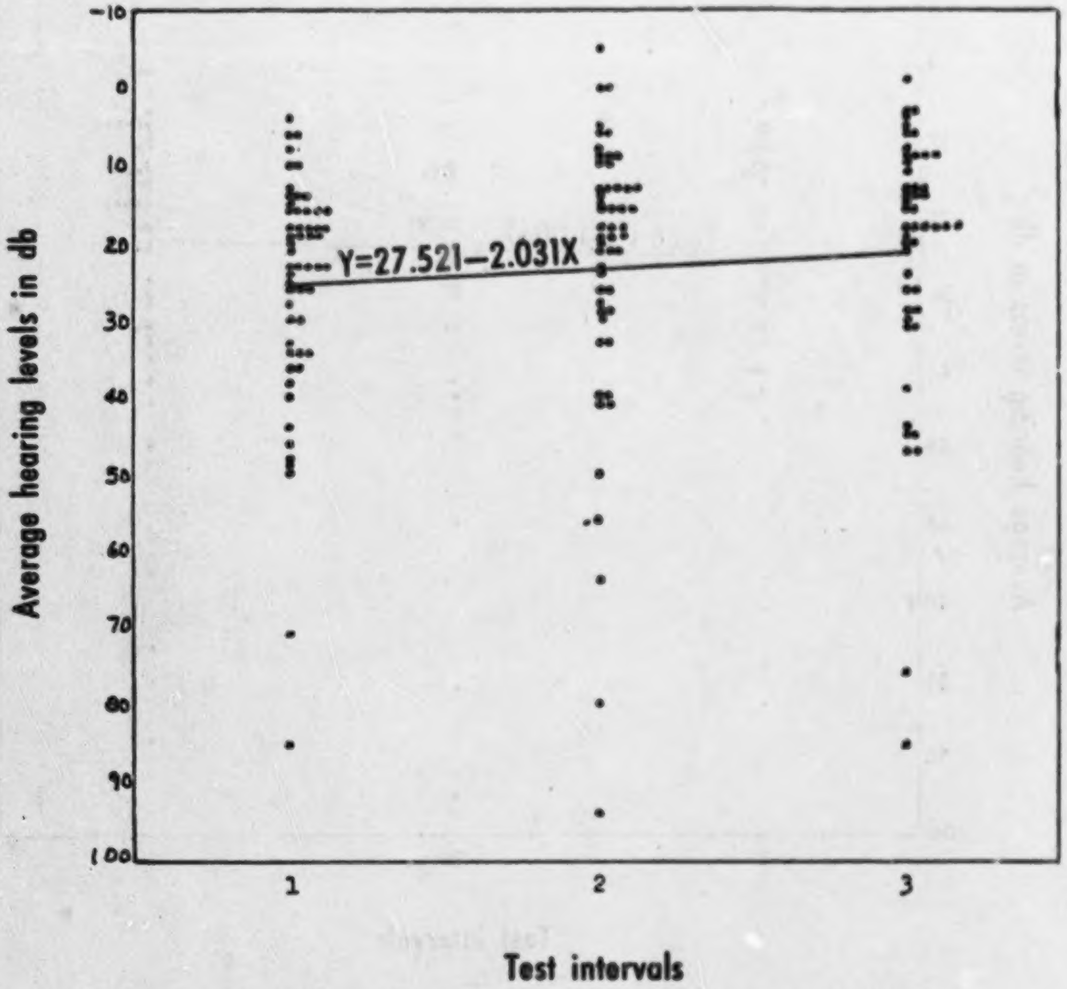

FIGURE 3. Sample regression of Play Audiometry average thresholds (right ear) on time.

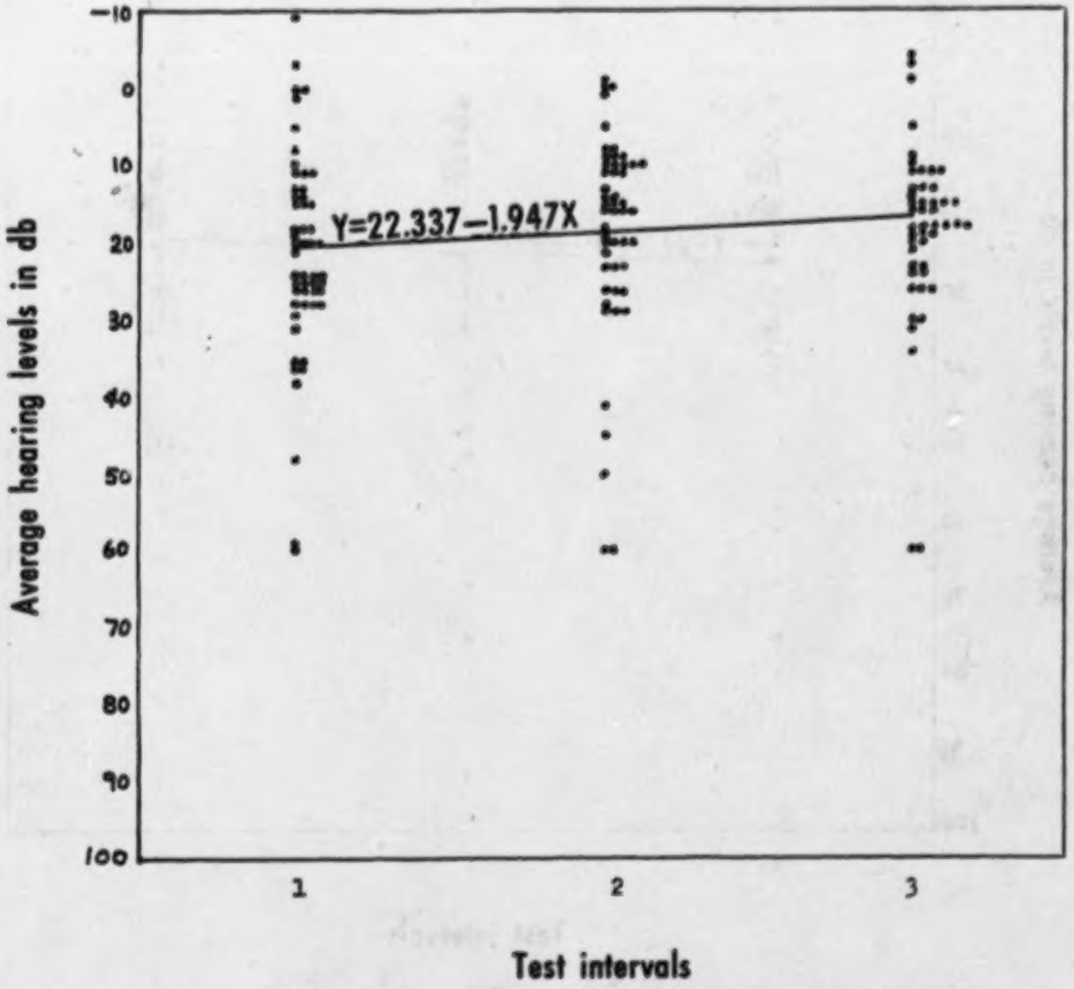

FIGURE 4. Sample regression of Bone Conduction Audiometry average thresholds (right ear) on time.

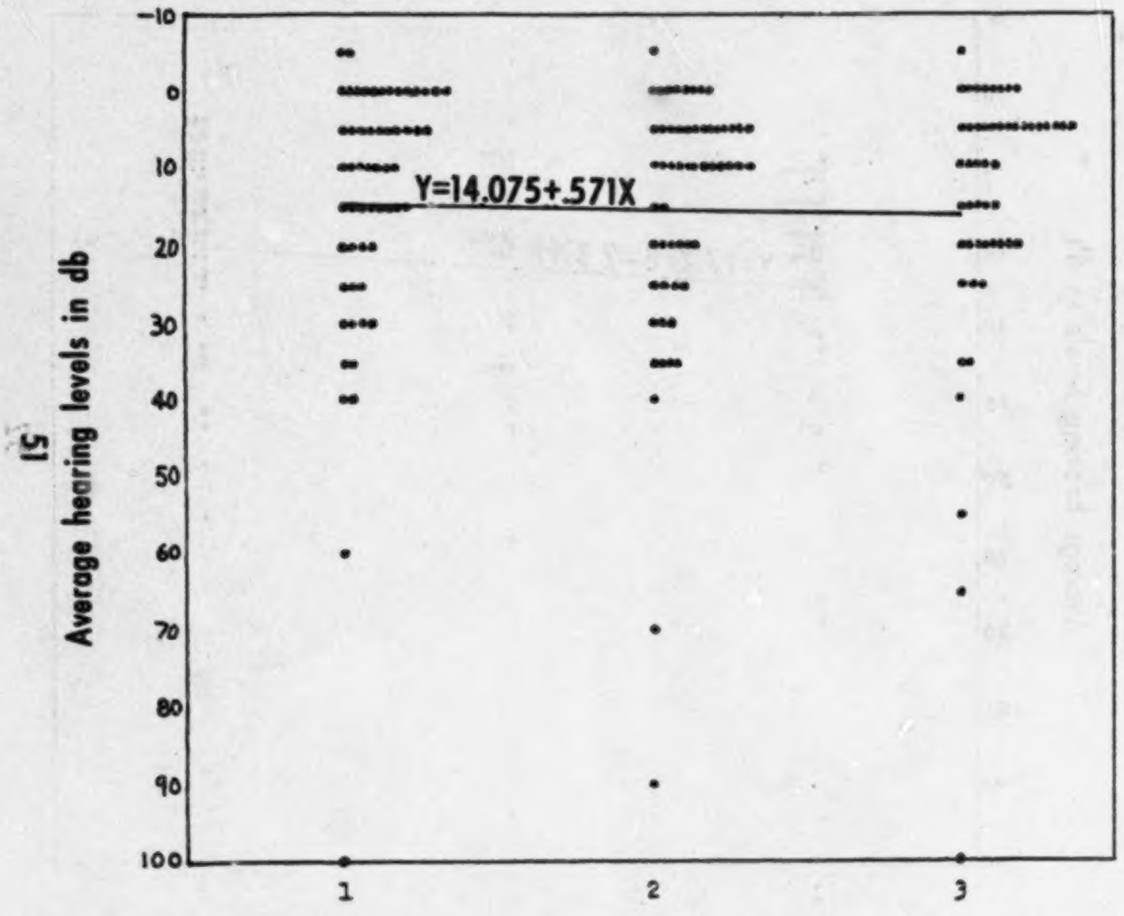

FIGURE 5. Sample regression of SRT Audiometry average thresholds (right ear) on time.

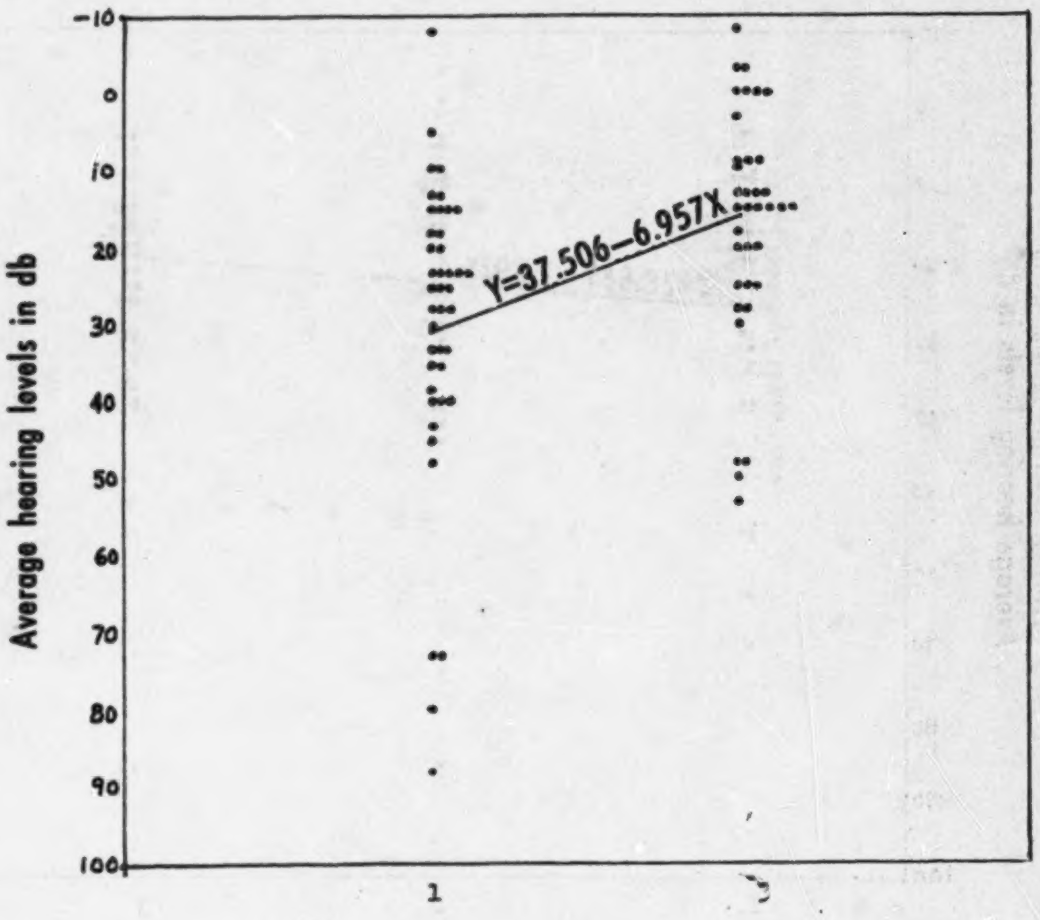

FIGURE 6. Sample regression of GSR Audiometry average thresholds (right ear) on time.

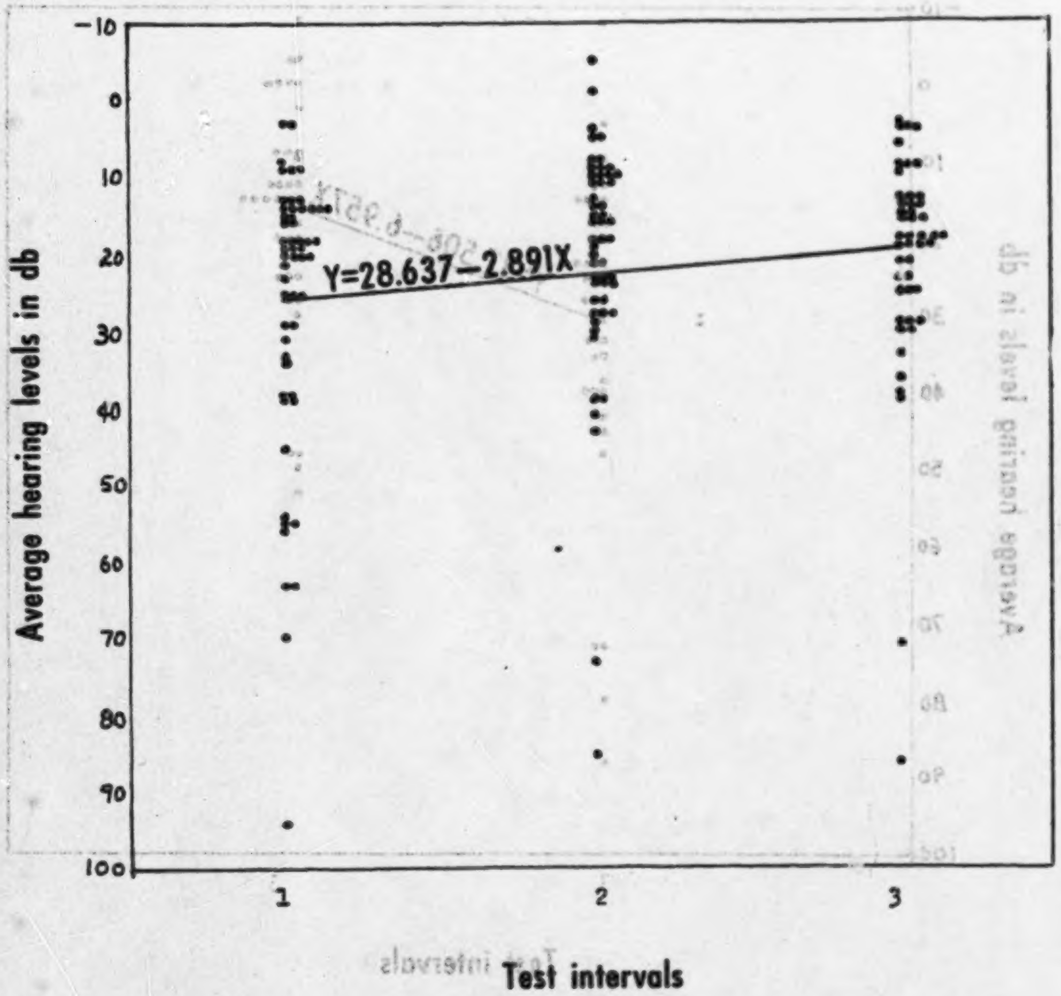

FIGURE 7. Sample regression of Standard Audiometry average thresholds (left ear) on time.

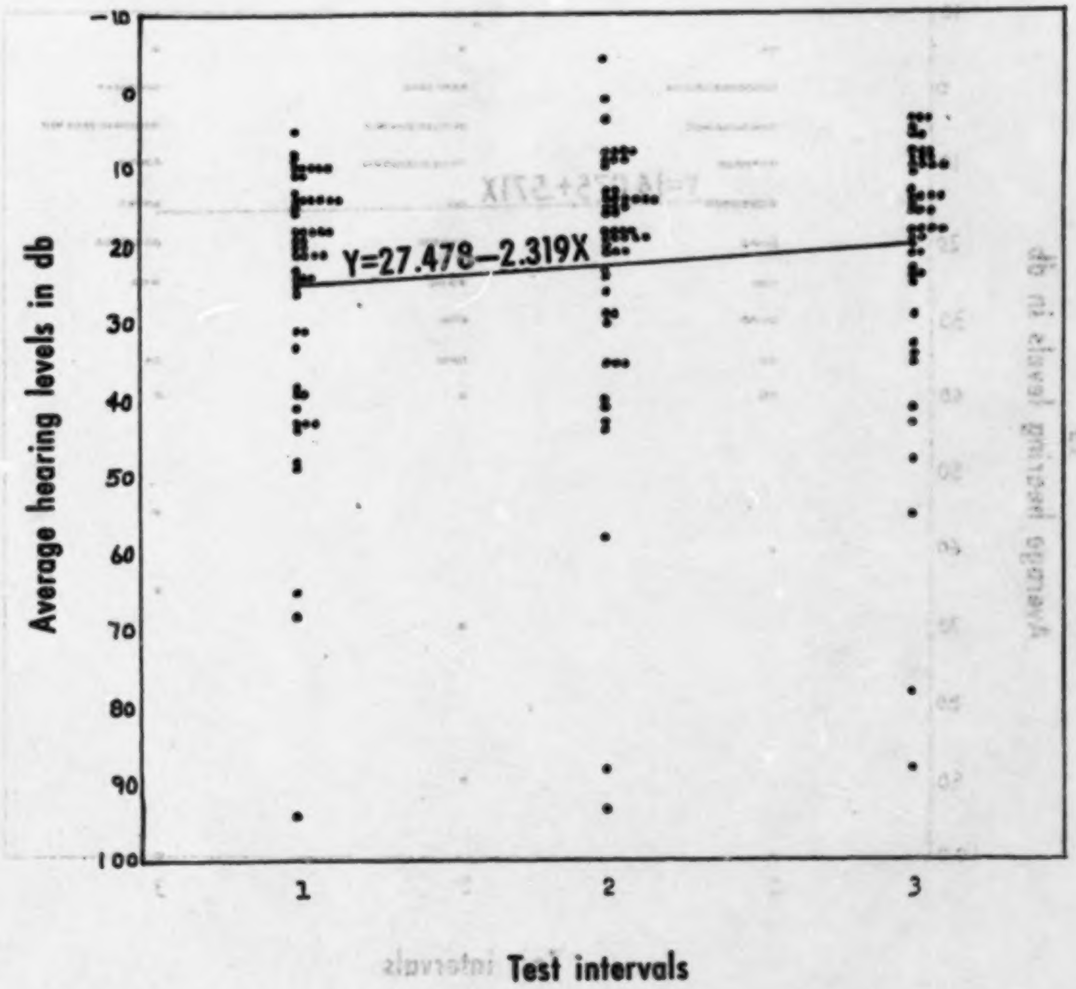

FIGURE 8. Sample regression of Ear-Choice Audiometry average thresholds (left ear) on time.

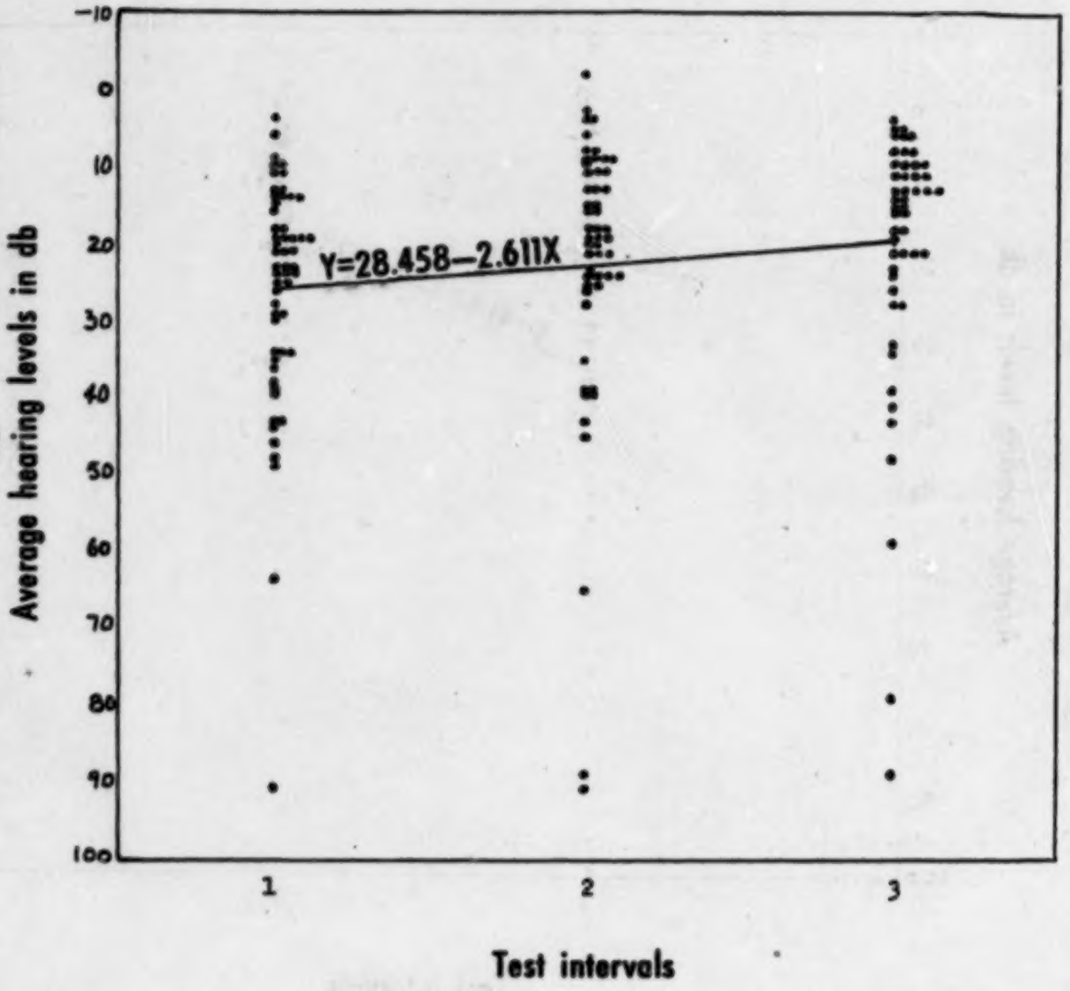

FIGURE 9. Sample regression of Play Audiometry average thresholds(left ear) on time.

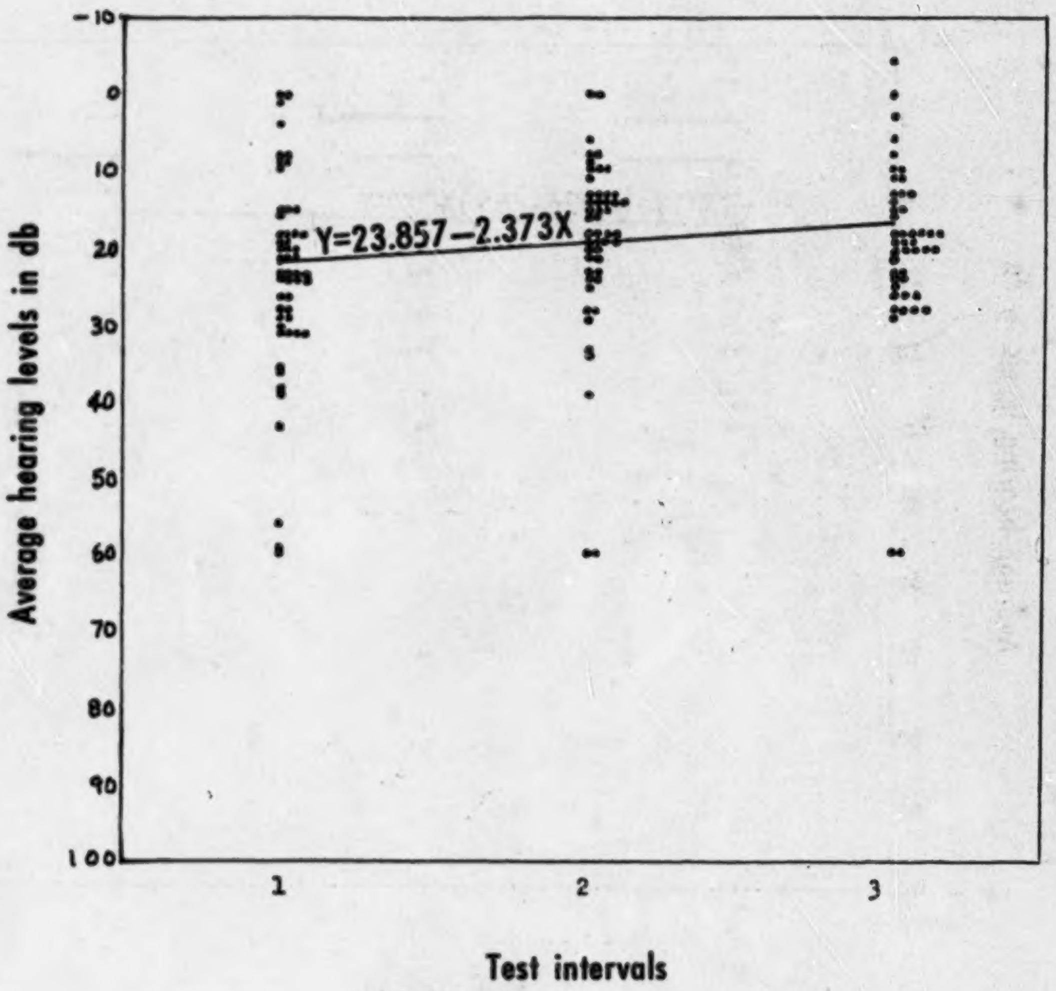

FIGURE 10. Sample regression of Bone Conduction Audiometry average thresholds (left ear) on time.

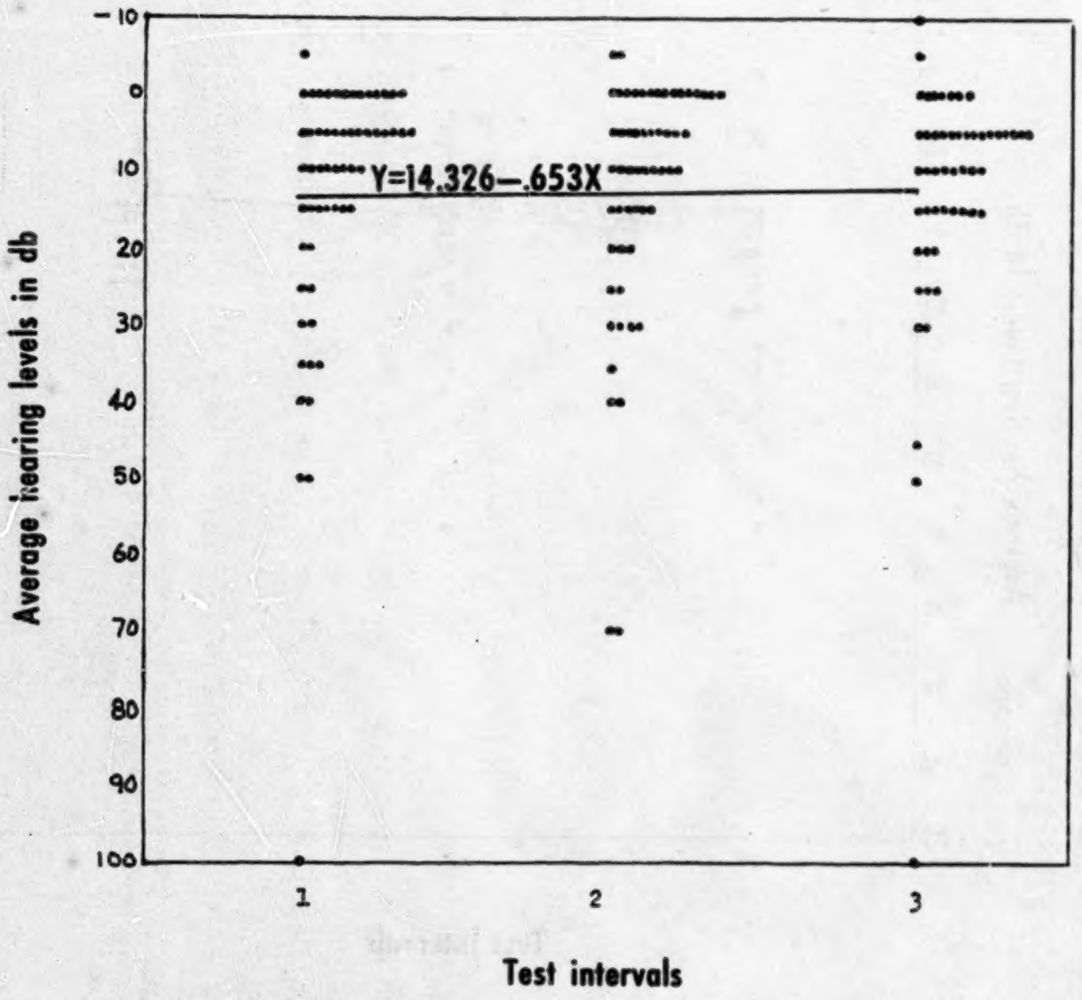

FIGURE 11. Sample regression of SRT Audiometry average thresholds (left ear) on time.

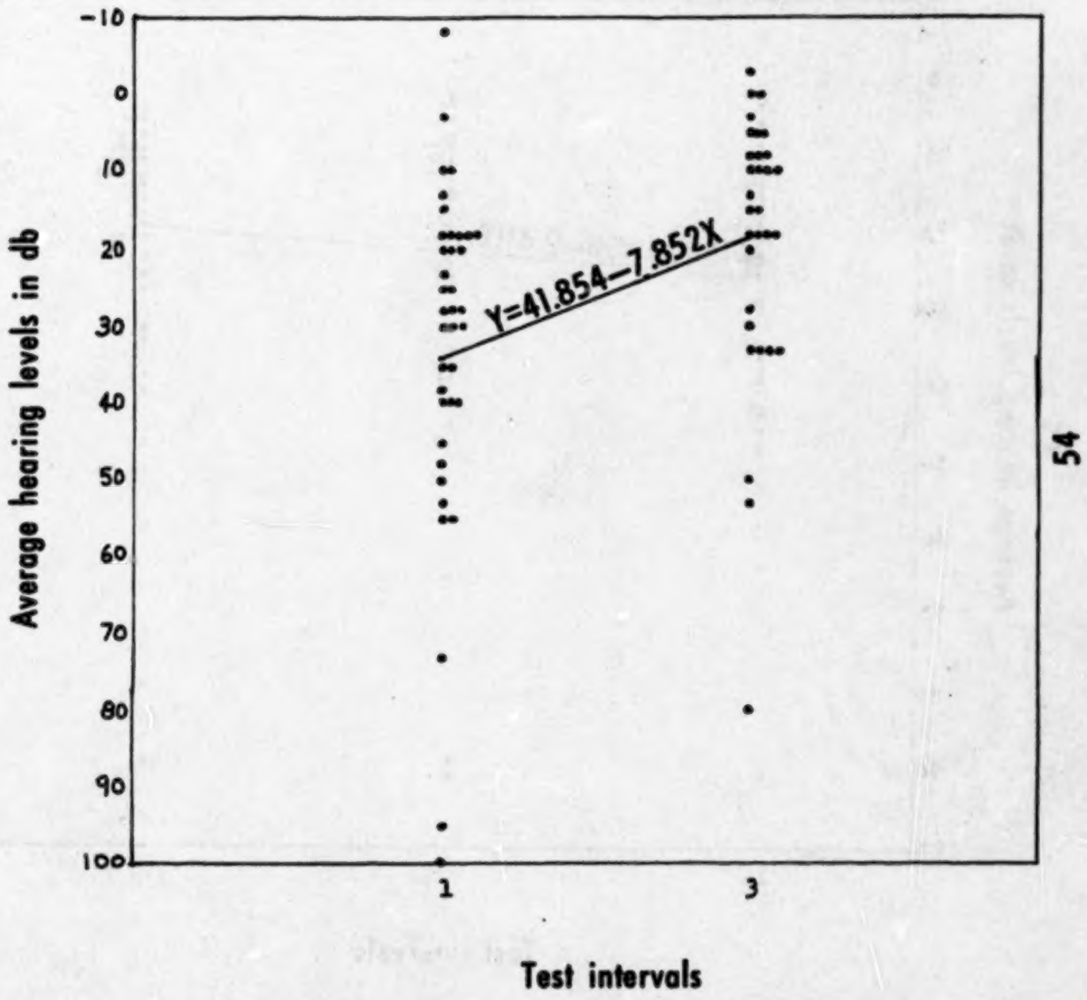

FIGURE 12. Sample regression of GSR Audiometry average thresholds (left ear) on time.

Regression of Audiometric Thresholds on Time

Sample regressions of the various audiometric average thresholds on time are shown in Figures I - I2. The mean thresholds for each individual (Y, the dependant variable) for each time of test (X, the independant variable) are represented by dots on the graphs. The point estimates of the slope, β, are also represented on the graphs.

Table 4 gives the estimated rates of change in average hearing thresholds on time. Confidence levels are also indicated. All of the sample regression coefficients are negative with the exception of the SRT test, right ear. The minus sign is indicative that the hearing threshold decreases with time. Such factors as familiarity with the tests, awareness of sound through

TABLE 4

Estimated Rates of Change in Average Hearing
Thresholds over Spaced Test Intervals

Ear	Audiometric Test	95% Confidence Interval Estimates of Rate of Change
Right	Standard	-1.635 ± 3.416
	Ear-Choice	-1.004 ± 3.544
	Play	-2.031 ± 3.312
	Bone Conduction	-1.947 ± 2.135
	SRT	+0.571 ± 3.390
	GSR	-6.957 ± 3.950*
Left	Standard	-2.891 ± 3.288
	Ear-Choice	-2.319 ± 3.394
	Play	-2.611 ± 3.321
	Bone Conduction	-2.373 ± 1.980
	SRT	-0.653 ± 3.193
	GSR	-7.852 ± 4.776*

* Five per cent level of confidence.

training, an augmenting of security in recognition of sound and thresholds that are too high in initial testing would account for this. Although the data indicate a change in hearing thresholds over spaced test intervals, the data are not sufficient to establish these changes as being real with one exception. The data do establish the change in GSR audiometry to be real at the 95 per cent level of confidence.

Subjects with Losses in Individual Audiometric Tests under Varying Criteria

In this section the various audiometric tests will be considered individually to determine if there is a reduction in subjects with hearing losses from Interval I to Interval 3 using various criteria for a loss. All of the 65 subjects were included in the first interval. Final testing does not include Group O, the seven subjects who left the institution after the initial battery of tests had been administered. The data were perused independently of either ear. If the poorer ear of the subject met the criteria for hearing loss as indicated in Tables 5 through 9, the subject was included in the appropriate grouping.

A look at Table 5 will illustrate a foregone conclusion, viz., that as the criteria for hearing loss become greater, the number of subjects with hearing loss increases. As an example, in initial testing 43 subjects had responses in two of the four frequencies (500, 1000, 2000, 4000) tested, in one ear, at 20 db or greater. Twenty-five subjects in initial testing responded with losses of 30 db or greater in two frequencies. Recalling that in the screening, all of the 65 subjects responded at 30 db or greater, or did not respond, this could be considered a substantial reduction in subjects with losses at that criterion. Further reductions are noted in a glance at the final column under this same criterion for the number was reduced from 25 subjects to 14 subjects. The use of an average decibel threshold, such as 20 db or 30 db, will, of

TABLE 5

Number of Subjects Whose Hearing Loss by
Standard Pure Tone Audiometry in Either Ear
Met Various Criteria at Initial and Final Testing

Criteria	Initial (N=65)	Final* (N=52)
Two frequencies at 20 db or Greater	43	37
Two frequencies at 30 db or Greater	25	14
Average 20 db or Greater	35	28
Average 30 db or Greater	21	14
Could Not Test	11	4

* Seven subjects not included in final. Initially three had 20 db or greater losses, one had 30 db or greater, one could not be tested and two had normal responses.

course, decrease the incidence of loss in a group. As seen in Table 5, the use of average thresholds reduces slightly the number of subjects with losses. No matter which criterion was used, final testing found from 6 to 11 subjects less than in initial testing under the various criteria for hearing losses. The untestable group of 11 subjects, one of whom did not receive final testing, was reduced to four.

Tables 6, 7, and 8 present the same pattern as the above. Numbers of subjects failing to meet the various criteria for hearing loss are approximately the same as in standard audiometry. The trend in reducing the numbers with hearing losses is the same with less subjects under the more severe criteria as well as in final testing. Bone conduction audiometry had seven in the

TABLE 6

Number of Subjects Whose Hearing Loss by Ear-Choice Audiometry in Either Ear Met Various Criteria at Initial and Final Testing

Criteria	Initial (N=65)	Final* (N=58)
Two frequencies at 20 db or Greater	38	33
Two frequencies at 30 db or Greater	21	17
Average 20 db or Greater	35	23
Average 30 db or Greater	20	15
Could Not Test	11	3

* Seven subjects not included in final. Three had 20 db or greater responses, one had 20 db average or greater losses, one could not be tested and three responded normally.

TABLE 7

Number of Subjects Whose Hearing Loss by Play Audiometry in Either Ear Met Various Criteria at Initial and Final Testing

Criteria	Initial (N=65)	Final* (N=58)
Two frequencies at 20 db or Greater	44	32
Two frequencies at 30 db or Greater	29	17
Average 20 db or Greater	42	25
Average 30 db or Greater	24	13
Could Not Test	10	3

* Seven subjects not included in final. Four had 20 db average or greater losses, one had 30 db or greater losses, one could not be tested and two responded normally.

TABLE 8

Number of Subjects Whose Hearing Loss by Bone Conduction Audiometry in Either Ear Met Various Criteria at Initial and Final Testing

Criteria	Initial (N=65)	Final* (N=58)
Two frequencies at 20 db or Greater	44	37
Two frequencies at 30 db or Greater	23	15
Average 20 db or Greater	38	31
Average 30 db or Greater	16	10
Could Not Test	12	7

* Seven subjects not included in final testing. Five averaged 20 db or greater losses, one was normal and one child could not be tested.

non-testable category, the greatest number of non-testables than any of the pure tone tests covered above. This can be accounted for by the fact that two of the subjects had moderately severe neural losses. Therefore, it was not a question of whether or not the subjects were capable of responding; there was an actual neural loss whose threshold can not be determined by bone conduction audiometry.

Speech audiometry results indicating the number of subjects with losses at various criteria are indicated in Table 9. Whether the initial interval results using an average or two frequency criteria at 20 db or 30 db of the preceding tests are compared with the SRT results, it can be seen that roughly half as many are considered to have a hearing loss under SRT testing as in the other tests. Play audiometry (Table 7), for example, shows 44 subjects with losses at the cri-

TABLE 9

Initial and Final Results Indicating Number of Subjects with Losses in Either Ear by SRT Audiometry

Criteria	Initial (N=65)	Final* (N=58)
20 db or Greater	20	18
30 db or Greater	11	10
Could Not Test	6	1

* Seven subjects were not available for final testing. Five demonstrated no loss in initial testing, while two had losses of 25 db or greater.

terion of two frequencies at 20 db or greater and 42 with an average loss of 20 db or greater. SRT audiometry in initial testing has 20 subjects with a 20 db understandability threshold. Using the criteria of 30 db or greater at two frequencies and a 30 db or greater average, play audiometry has, respectively, 29 and 24 subjects with hearing loss as compared to only 11 subjects with 30 db or greater losses. The same comparisons made with the other tests give closely similar results. Only six subjects did not respond to SRT testing, initially, as compared to 10 to 12 subjects in the preceding tests. Only one of the 58 subjects taking the final SRT test could not or would not respond. It is interesting to note, also, that there was only a minimal change in numbers from initial testing to final testing in the SRT technique. Eighteen subjects had 20 db or greater losses in the final test as compared to 20 subjects initially, and 11 had 30 db or greater losses initially compared to a final total of 10. This reduction in numbers was much less than in the other tests used.

A count was also made of the subjects responding to SRT at 15 db or greater in either ear. Twenty-nine of the subjects responded at this level or greater. In final testing, 27 subjects responded at 15 db or greater thresholds. Even with this more stringent criteria 28 subjects (27 subjects at 15 db and one "untestable") had less hearing losses with SRT than with the other tests.

The lowest thresholds were obtained by SRT audiometry with the majority of subjects. In the initial testing of 65 subjects, right ear only, SRT thresholds compared to other test results were lower in 46 subjects in at least four out of five (bone conduction test not included) average thresholds. In final testing of 58 subjects, 42 obtained lower thresholds in at least four out of five different test thresholds. Four subjects (A37, B2, B6 and B7) who would not respond to most other test techniques responded to SRT audiometry in either initial or final testing intervals.

The number of subjects who failed to meet average hearing threshold criteria by GSR audiometry in initial and final testing intervals are presented in Table 10. The trend is somewhat the

TABLE 10

GSR Audiometric Average Hearing Thresholds (1000 and 4000 cps) Indicating Number of Subjects Whose Hearing Loss in Either Ear Met Various Criteria at Initial and Final Testing

Criteria	Initial (N=58)	Final* (N=52)
Average 20 db or Greater	35	16
Average 30 db or Greater	21	10
Could Not Test	17	14

* Seven of total subjects not included in initial test. Of five subjects given initial tests who were not tested in the final battery, one had a 20 db or greater loss, two had 30 db or greater losses, one could not be tested and one had normal threshold.

same in this test as in the others. Approximately the same number of subjects faitially failed the criterion of an average of 20 db or greater as failed in the other tests. The same pattern is true for the 30 db average or greater. However, a decided drop takes place in the final interval of testing when 16 subjects failed the criterion of an average of 20 db or greater as compared to higher numbers in the other tests. One factor contributing to the smaller number of subjects failed the final testing in GSR audiometry is that there is a large number of subjects who could not be tested initially as well as finally. Another point to consider is that GSR audiometry used but two frequencies, 1000 cps and 4000 cps. This might have reduced the average slightly. For a summary comparison of the number of subjects who failed the 20 db and 30 db average or greater criteria, as well as the number of subjects who failed to respond to testing, see Table 11.

TABLE 11

Number of Subjects Whose Hearing Loss in Either Ear in All Tests Exceeded Stated Criteria

				Tests			
Criteria	Interval	SRT	GSR	Standard	Ear-Choice	Play	BC
20 db Average	I	20	35	35	35	42	38
	F	18	16	28	23	25	31
30 db Average	I	11	21	21	20	24	26
	F	10	10	14	15	13	10
Could Not Test	I	6	17	11	11	10	12
	F	1	14	4	3	3	7

In initial standard audiometry procedures 11 subjects could not respond to the test stimuli. In final testing, four of the 11 continued unable to respond, two of the subjects responded normally, one had a 20 db average loss, and three had 30 db or greater losses. One subject who responded normally in initial testing could not be tested in the final test. Only one of the seven subjects who were not available for final testing would not respond to the test stimuli. In the ear-choice technique of 11 subjects who did not respond initially, three continued not responding in this test. Seven demonstrated losses as follows: two frequencies at 20 db, two subjects averaged a 20 db loss and three averaged a 30 db loss. Of the seven subjects not included in the final testing, only one was unable to respond to this test. In play audiometry, ten subjects could not respond in the initial examination. In the final examination, three were unable to respond adequately, one responded normally. Five demonstrated losses as follows: three had losses averaging 20 db and two had losses averaging 30 db. One of the seven subjects not included in final testing could not be tested. Among the six subjects who were unable to respond to speech reception threshold testing at the initial administration, one did not respond finally and one subject responded normally. Two subjects responded at 20 db and two at 30 db or greater. Seventeen subjects could not be tested initially with GSR audiometry in initial testing. This 17 was reduced to nine subjects in the final interval of testing. However, an additional five subjects who were tested the first time were not testable in the final procedures. This made a total of 14 subjects who were not testable with GSR procedures in the final interval. One who could not be tested initially had a 30 db loss or greater and one had a loss greater than 20 db.

Relationship Between Standard and Speech Reception Audiometry

The average thresholds of the standard audiometric test for the right ear at both intervals and speech reception thresholds were considered to determine if a relationship existed between these results. The choice of standard audiometry for the determination of this relationship was made as this is the type of pure tone threshold technique used in most hearing testing. Pearson-product-moment correlations were computed and the results are found in Table 12.

TABLE 12

Correlation Between Standard Audiometric and Speech Reception Threshold for Right Ear at Initial and Final Test Intervals.

Interval	N	_r_
Initial	49	.764**
Final	47	.797**

** One per cent level of confidence.

A correlation of .764 was obtained in initial testing, while the _r_ was .797 in the final test. It was not anticipated that the two audiometric tests would correlate perfectly since they measure somewhat different capacities with different stimuli. Nevertheless, the obtained relationships were significant at the l per cent level of confidence. This relationship seems to improve after repeated testing and/or training in listening.

A Comparison of GSR and Standard Audiometry

While the stimulus, speech, of speech audiometry and that of standard pure tone testing differ, GSR and standard audiometry use the same stimulus. It is the conditioned responses that are different. Standard responses are under the volition of the subject, while GSR audiometric responses are non-volitional. A comparison of best ear threshold responses at 100 cps at both initial and final intervals of testing was made using the _t_ - test of the signifficance of the difference between the means. The results are found in Table 13. In initial tests, the mean threshold of GSR was 26.4 db as compared to 23.4 db of standard audiometry. A _t_ score of .733 was not significant. The final test mean of 12.4 db for GSR audiometry and 17.2 db for standard audiometry was also not significant. Within the limitations noted previously, results from these two tests are approximately the same. It should be noted, however, that differences in several cases were greater than 20 db and that a comparison of the majority of the scores indicated differences of + 10 db.

TABLE 13

Test	Initial,			Final		
	N*	Mean	t	N	Mean	t
GSR	36	26.4		37	12.4	
Standard	43	23.4	.733(n.s.)	46	17.2	1.070(n.s.)

* Number varies because of inability to test some of subjects at interval indicated.

Judgment of Subject Responses to GSR Audiometry

In the evalustion of the use of an audiometric test, many factors should be taken into consideration. The GSR audiometric testing used in this investigation, although obtaining thresholds that were not significantly different at 1000 cps from those of standard audiometry and approximating average threshold of the other tests, nevertheless, offers negative aspects which prevent its being the audiometric test selected where a choice is offered. Apart from the complicated mechanical aspects of its functioning, its traumatic effects on some subjects, and the need for two people to adminster the test with children or subjects such as those of this research, there is the need at times for the examiner to make judgments as to the response. This involves a relationship between the subjects and the examiner and the test situation which complicates results which are dependent on a normal autonomic nervous system. Moss, Moss and Tizard (64) found electrodermal response audiometry (GSR) of limited utility with mentally defective children. Because of behavioral reasons they were unable to test 34 of 58 institutionalized mental defectives. Records were classified as good, fair, or poor for records obtained. Only 27 per cent could be rated as good or fair.

Using an adaptation of their descriptive ratings, but broadening the base for judgments to include subject behavior, the subjects of this research were given good, fair and poor ratings based on performance records and behavior during testing at both initial and final testing. Ratings were based on the following:

Poor:	inadequate unconditioned responses, spontaneous fluctuations, scoring difficult or impossible.
Fair:	labile record with spontaneous fluctuations but with responses still generally scorable.
Good:	record stable with a minimum of spontaneous fluctuations, responses generally scorable with confidence.

Table 14 indicates the ratings by two judges who participated in the GSR audiometric procedures. Only five subjects were rated good. Adding this to the 18 subjects rated fair, gives a total of 23 of 51 responses with scorable performance, or 45 per cent, which is slightly higher than the 27 per cent of Moss, et al. This points up the difficulties in the use of such equipment and methods for testing the hearing of mentally retarded children, particularly when they are as low intellectually as the subjects of this study.

TABLE 14

Ratings of Subject Responses to GSR Audiometry
N 51

Poor	Fair	Good
28	18	5

Type and Severity of Hearing Loss

The subjects who consistently demonstrated hearing losses were categorized in terms of the severity of their loss and the type of loss indicated on the basis of responses to standard air and bone conduction pure tone tests. Table 15 indicates the severity of loss and the type of loss by ear, and Table 16, the type of loss according to number of subjects. Because of the fact that the subjects responded somewhat identically to stimuli for both ears, the categorization by subjects is roughly half that of by ear.

Neural losses predominate, as might be expected, in a low grade group of mentally retarded subjects, since etiology of mental retardation and hearing loss might be causal for both. Rigrodsky, Prunty and Glovsky (73) found that their population with neural and mixed losses were almost equally distributed with a much smaller percentage having conductive losses. Losses as seen in Table 15 indicate that the majority of ears demonstrating losses through standard air and bone conduction testing were in the mild hearing loss category (20-40 db).

TABLE 15

Type and Severity of Hearing Loss* by Ears, Based on a Comparison of Standard and Bone Conduction Audiometry.

Severity of Loss		Type of Loss	
	Neural	Conductive	Mixed
Mild (20-40 db)	19	8	5
Moderate (40-60 db)	4	1	1
Severe (60-75 db)	1	0	0
Profound (75-100 db)	3	0	0
Totals	27	9	6

* Any ear showing an average loss of at least 20 db at four frequencies, 500, 1000, 2000 and 4000 on the Standard Audiometric tests for the first and third intervals is listed. Neural losses were determined by the close agreement of the AC-BC curves. Conductive

losses were designated if at least a 10 db differential existed between the AC-BC curve at all frequencies. When the AC-BC curves were separated at one point and tended to meet at another, the loss was termed mixed.

TABLE 16

Type of Hearing Loss According to Number of Subjects

Type of Loss	Number of Subjects With Loss
Neural	15
Conductive	6
Mixed	3
Total	24

Relationships Between Selected Audiometric Tests and Variables CA, Stanford-Binet IQ and MA and the PPVT MA.

Three audiometric tests were selected to ascertain the relationship between chronological age and the thresholds obtained from these tests at the initial administration of the battery of hearing tests. Because of the varied responses used in these tests, standard, GSR, and SRT audiometry were selected. The results are given in Table 17.

The only audiometric test demonstrating a significant relationship with chronological age was the standard air conduction test with an r of .275. This is significant at the 5 per cent level of confidence. All measures are positive, indicating a slight increase in thresholds with an increase in CA. It is possible that as the mental retardate becomes older, more problems effect his interpersonal interactions and thereby react on his response to hearing stimuli. Only when it is loud, does he have the confidence to respond.

TABLE 17

Relationships in Initial Testing Between CA and Three Audiometric Tests

Test	N	Mean	r
CA	52	191.3 mos.	
Standard	52	26.2 db	.275**
CA	41	197.3 mos.	
GSR	41	30.9 db	.196
CA	54	187.1 mos.	
SRT	54	15.2 db	.106

* Significant at 5 per cent level of confidence.

Table 18 indicates the relationship between the Stanford-Binet mental age and the same three tests. All correlations are negative. This indicates that as MA increases thresholds decrease. However, only the SRT and mental age show a significant relationship of -.363. This r was significant at the 5 per cent confidence level.

TABLE 18

Relationships in Initial Testing Between Stanford Binet MA and Three Audiometric Tests

Test	N	Mean	r
SBMA	46	66.4 mos.	
Standard	46	25.6 db	-.135
SBMA	40	64.0 mos.	
GSR	40	29.5 db	-.054
SBMA	48	62.6 mos.	
SRT	48	13.6 db	-.363*

*Significant at 5 per cent level of confidence.

TABLE 19

Correlations Between the Stanford-Binet IQ and Initial Right Ear Thresholds of Selected Audiometric Tests.

Test	N	Mean	r
IQ	46	39.174	
Standard	46	25.587	-.216
IQ	40	37.725	
GSR	40	29.500	-.104
IQ	48	37.271	
SRT	48	13.333	-.422**

** Significant at 1 per cent level of confidence.

Using these three audiometric tests, the relationship with the Stanford-Binet intelligence quotient was explored. Correlations, as shown in Table 19, are negative, which indicates a decrease in hearing thresholds with an increase in IQ. The only significant relationship was that between the speech audiometric test and IQ. The r was -.422, which was significant at the 1 per cent level of confidence.

For these mentally retarded subjects with mental age means between five and five years, six months, and intelligence quotient means between 37 and 39, speech reception audiometry appears to demonstrate the most significant relationship.

Interestingly enough, and not surprisingly, a significant relationship was shown between SRT audiometry and the Peabody Picture Vocabulary Test mental age at the first interval of testing. Table 20 gives this information. The r between the PPVT MA and SRT thresholds was -.411, significant at the 1 per cent level of confidence. The relationship is almost non-existant at the second interval since SRT responses for the most part remained static while PPVT mental ages gained slightly.

The r of -.411 is approximately the relationship between the SRT test and the Binet IQ and MA.

TABLE 20

Pearson Product-Moment Correlations Between Peabody Picture Vocabulary Test MA and Speech Reception Thresholds for Right Ear at Initial and Final Testing.

Test	N	Initial Mean	r	N	Final Mean	r
PPVT	55	52.4	-.411**	51	56.0	-.073
SRT	55	13.9		51	15.9	

** One per cent level of confidence.

Comparison of Initial and Final Administrations of Intelligence Test Mental Ages

In addition to determining if there were any changes in audiometric thresholds over a period of time, intelligence tests were given at the time the initial battery of hearing tests were administered and at the conclusion of the listening program when the final battery of hearing tests were given. Table 21 offers the information comparing test-retest mental age scores obtained by Stanford-Binet and Peabody Picture Vocabulary tests. The initial test mean of 61.4 ± 3.18 months of the Stanford-Binet increased to 65.1 ± 3.23 months, a mean gain of 3.7 months. Using the t-test, this was found not significant. The mean gain of 3.5 months of mental age obtained by subtracting the PPVT initial and final mental age scores was also not significant. Viewing this mean gain empirically, it would appear to be larger than one would anticipate in a group whose mean mental age by Binet testing was 5 years, one month, and whose IQ mean was 36. Perhaps they underperformed in initial testing, or perhaps the greater-than-expected gains were due to training in listening. An interesting note is the difference in scores between the two tests. The eight-month difference could be a reflection of verbal reception abilities of the subjects.

TABLE 21

Significance in Difference Between the Mental Age Means of Initial and Final Administrations of (a) Stanford-Binet and (b) Peabody Picture Vocabulary Tests

Test	N	Initial Mean (months)	S.D.	N	Final Mean (months)	S.D.	t
SB	56	61.4	3.18	53	65.1	3.23	.822 (n.s.)
PPVT	64	52.9	3.3	57	56.4	3.42	.732 (n.s.)

Listening Training Program Results as Measured by a Direction of Change

Up to this point the effects of a listening training program have been evaluated by the amount of change in such measures as various audiometric tests and intelligence tests given periodically. Various artifacts are present in any repetition of measures over a period of time. It is usually considered a normal variation to have repeated audiometric tests, for example, vary up to five decibels in either direction. The data have indicated slight changes over time in magnitude of audiometric and intelligence test results. Emphasis is also needed in the direction of change in hearing thresholds and intelligence testing.

The McNemar Test for Significance of Changes[1] was used to indicate the effectiveness of the program of listening training. Defining positive changes as an improvement in auditory thresholds which is demonstrated by a response at a lower intensity and a negative change as a response at a higher intensity, a count was made, using Group A only, of changes in each test threshold at the various testing intervals. The results are indicated in Table 22. It can be seen by viewing the Probability, or "levels of confidence" column, that the changes were significant in a positive direction in at least two of three testing intervals and in play and ear-choice audiometry in all intervals. SRT changes were not significant in either direction at all intervals. It would appear from these observations that the listening training program improved thresholds somewhat significantly in direction as well as slightly in magnitude. More significantly, however, the program stabilized thresholds as well as forestalled regression in auditory acuity. If there were random threshold variations brought about by such artifacts as noise, physiological and psychological deviations, there would not have been, theoretically, significant changes in the direction of threshold scores.

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[1] The statistical procedures used in the McNemar Test for Significance of Changes are from: Siegel, S., Nonparametric Statistics for the Behavioral Sciences. New York: McGraw-Hill, 1956, pp. 63-67.

Table 22 also indicates that it is possible that extended listening training is of doubtful efficacy in improving standard air and bone conduction testing with the mentally retarded. No significant changes were found in threshold between the first and second and first and third intervals in standard audiometry and first and third intervals in bone conduction.

The fact that there were no significant changes in the direction of threshold scores obtained by SRT testing had implications which have been commented on previously. The subjects may have responded at valid thresholds in the initial testing, and therefore, further improvement in threshold scores was not possible. Secondly, the fact that SRT responses were consistently better than the pure tone thresholds supports the observations that individuals may have difficulties other than auditory acuity affecting auditory threshold responses and additional loudness levels are necessary before reliable responses to pure tones can be obtained (37).

TABLE 22

Direction and Number of Auditory Threshold Changes for Each Test at Each Interval with Probabilities Related to the Changes

Audiometric Test	Intervals	Changes			
		Positive	Negative	Same	Probability
Play	1 to 2	29	12	2	.02
	2 to 3	27	11	2	.02
	1 to 3	34	5	3	.001
Ear-Choice	1 to 2	30	11	2	.01
	2 to 3	28	13	1	.05
	1 to 3	34	7	1	.001
Standard	1 to 2	28	14	1	.05
	2 to 3	20	18	4	ns
	1 to 3	30	8	4	.001
Bone Conduction	1 to 2	27	14	2	ns
	2 to 3	18	20	5	ns
	1 to 3	28	12	3	.02
GSR*	1 to 3	28	8	5	.01
SRT	1 to 2	22	18	3	ns
	2 to 3	15	14	14	ns
	1 to 3	19	18	6	ns

* Not given at second interval.

The Stanford-Binet and PPVT mental ages were also scrutinized to determine the direction of change and ascertain the effects of listening training on the subjects. Table 23 indicates that changes occurred and at a level of confidence of less than 1 per cent.

TABLE 23

Significance of Changes in Stanford-Binet and PPVT Mental Ages from the First Interval to the Final Interval

Intelligence Test	Changes			
	Positive	Negative	Same	Probability
Stanford-Binet	35	0	8	.001
	32	6	5	.001

Ratings of communication interaction were given to the subjects. They were judged on a zero to five scale. Zero indicated poor communication responsiveness. Appendix 4 contains the basis for ratings and initial and final subjective ratings made on each of the 43 institutionalized subjects who participated in the entire program. Table 24 summarizes changes and indicates their significance.

TABLE 24

Significance of Changes Between First and Final Interval for Communication Interaction

Measure	Positive	Negative	Same	Probability
Judgment of Communication Interaction	19	6	18	.02

A change is indicated at the 5 per cent level of confidence.

Uncontrolled Factors Influencing the Effects of Listening Training

There are limitations to the amount of improvement one might anticipate among retarded subjects in intelligence scores, auditory thresholds and behavior. Such factors as static or progressive neural pathology, sedation, personality disturbances, biochemical pathology, and others exerted some continuing effect during the training and testing. These factors could not be controlled. In any retarded population there are so many clusters of multiple deviations accompanying and contributing to the retardation that controls are difficult to establish. Some of the subjects were receiving sedatives. In examining the performance of six subjects (A6, A12, A24, A30, A36 and O1), no clear cut pattern could be discerned. A12, with a normal GSR during the first interval, could not be tested in the final interval; A30, unable to respond to GSR the first time, responded normally in final testing. Another factor, etiology, was not considered, although with the majotity of the population attaining IQs from 23 to 49 it can be assumed that many would have some type of neurological involvement. Eight subjects, A13, A21, A40, A41, A42, B2, B6 and B7, were mongoloids. All had difficulty responding to all tests at their true thresholds. Scores fluctuated and all were difficult to condition to GSR audiometry. Occasional normal responses were encountered. The non-institutionalized mongoloids, B2, B6 and B7 were probably among the most negative of all the subjects in testing and training. The latter two were brothers. The only test to which these three responded with any degree of validity was the speech reception test. An interesting note along this same general line is that these three subjects maintained the same Stanford-Binet mental age, while all the institutionalized mongoloids showed gains in MA from five to eleven months with the exception of one subject, who gained one month. Limitations beyond the relationship with the examiners, test methods and training are factors influencing group summations. Additional information on each individual subject from other disciplines is always a necessity with these multiple-handicapped subjects. The following descriptive summaries of five subjects in this study emphasize the need for individual analysis involving multi-disciplinary programming and clinical description:

Subject A10 was a white male, born 10-7-42 and institutionalized 1-31-55. His initial MA on the Binet was four years, six months, on the Peabody MA, two years, eight months. He obtained normal or slight loss thresholds on all but GSR and bone conduction audiometric tests in the initial testing period. Following several lessons the instructors made the following comments: "Responses are inaccurate," "Unable to follow directions," "Can make no connection between sound and responses required," "Erratic and unpredictable," "Withdrawn," "Seems detached." The supervising physician of the institution reported that A10's behavior was very poor and that a progressively deteriorating condition was present in the central nervous system. At the final testing it was impossible to test this subject with GSR, bone conduction, and standard audiometric procedures. His threshold on the other test remained stable at normal threshold responses. The final testing with the Binet gave an MA of four years, nine months and the Peabody, three years, six months, indicating improved scores. Communication interaction score was zero, and behavior during GSR testing was rated as poor.

Subject A12 was a negro female, born 4-4-49 and institutionalized 7-18-60. She was under heavy sedation and anti-convulsants were used. The initial MA on the Binet was three years, nine months and on the Peabody, three years, one month. She responded with predominantly normal thresholds to all audiometric tests initially except GSR by which she could not be tested. The instructor made the following observations during the audiometric training period: "Good response," "Fair responses," "Didn't keep her mind on what she was doing," "Seems to be delaying her responses," "Easily confused, poor response," "Negative reactions," "Slow responses." The sedation seemed to have a great effect on responses to training and may account for the variations noted in these responses. While no seizures were observed during the training period, the sequelae seemed to be present at times. At the final testing period her MA was four years on the Binet, a slight gain, and two years, eleven months on the Peabody, a loss of two months. Communication interaction was rated as three, or good. Behavior during GSR testing was rated one, or poor. She responded to all audiometric tests in the final testing period. Thresholds had not changed appreciably with a normal threshold obtained through GSR audiometry.

Subject A19 was a white male born 12-29-49 and institutionalized 8-10-56. The initial MA on the Binet was three years, eleven months and on the Peabody, three years, two months. The subject responded reliably to all audiometric tests initially. "Good response," noted several times, "Good response but did not always follow directions exactly," "Likes to help others," Responds well to rhythm activities," "Does not keep mind on activities." Final MA in the Binet was four years, five months, a gain of six months, and on the Peabody three years, nine months, a seven-month gain. Communication interaction was rated four, or very good. Behavior during GSR testing was rated three, or good. Results to audiometric testing were interesting. Thresholds were slightly higher at the second testing interval. At the final testing period they had approached the initial results. It seemed that tones of higher intensity were needed to get response at each testing interval. These fluctuations could not be accounted for.

Subject A24 was a white male born 6-5-44 and institutionalized 12-12-53. He was under heavy sedation to control seizures. The initial MA on the Binet was two years, eleven months and on the Peabody, two years, one month. This subject was unable to respond to speech reception testing and play audiometry at the initial hearing battery testing period. During the second testing interval he was hospitalized because of severe convulsive seizures. He was testable the third interval with all procedures except GSR. Notes indicated he was: "Accurate," "He is hallucinating, thinks he is the Lone Ranger," "Usually not accurate," "Poor response, fails to follow directions," "More reliable than before," "Not dependable at all; says he is Gene Autry," "Questionable responses." In addition to this he seemed to be experiencing auditory and visual hallucinations at different training periods. On occasion he came to the training periods with severe head hematoma from falls resulting from seizures, his head completely bandaged. Final MA on the Binet was three years, six months, a seven-month advance, and on the Peabody, two years, six months, a five-month gain. His communication interaction score was rated one, or poor, and behavior during GSR testing was one, or poor. He responded to all audiometric tests except GSR at the final testing interval.

Subject A35 was a white male born 10-11-43 and institutionalized 8-16-55. His initial MA on the Binet was four years, eight months and on the Peabody, it was three years, nine months. Threshold response indicating slight losses were reliable on all audiometric tests at the initial testing. During the training period the following observations were made: "Quick accuracte responses," "Accurate responses," "Would rather talk," "Has difficulty keeping his mind on activity," "Has difficulty in attending the lessons," "Talks too much," "Confused," "Good response." This subject displayed rather definite behavior disorders. His ideation was unusual and he verbalized and talked much more than the normal person. He was flighty and hyper-distractable. At the final testing interval his MA on the Binet was five years, four months, a gain of eight months and on the Peabody, four years, two months, a five-month advance. He responded reliably to all final audiometric tests with thresholds similar to initial test results. His final communication interaction score was two, or fair, and behavior during GSR tests was rated one, or poor.

CONCLUSIONS AND RECOMMENDATIONS

It was pointed out earlier in this investigation that any attempt at arriving at an incidence of hearing loss among mentally retarded children becomes a question of any one of several variables, such as the criteria for a loss established by the investigator, the locus of the investigation, the range and etiology of the retardation among the subjects, and the test or test methods used.

In this investigation, with a higher criterion than is usually established for hearing loss (30 db at two frequencies in the speech frequency range), 77 of 199 subjects tested failed the standard air conduction audiometric screening examination. This makes an incidence of hearing loss of 38.7 per cent among subjects tested. A second screening test using the same methods reduced the number with hearing loss responses to 65 subjects, or an incidence of 32.7 per cent. At the initial testing period, using the same type of response and testing for thresholds at all frequencies with standard audiometric techniques, 25 subjects failed, reducing the incidence of hearing loss to 12.5 per cent. Eleven subjects could not be tested and were not included in the statistic. Addition of this group to the total gives an incidence of loss of 18 per cent. In the final examination after listening training, 14 subjects, an incidence of 7 per cent, failed to attain thresholds established at the above criterion. Four subjects could not be tested. The addition of these subjects raises the incidence of loss to 9 per cent. This is an illustration of what repeated testing can accomplish. Of course, if a lower criterion were used, the per cent of incidence of loss would be greater.

It should also be pointed out that only 199 of a possible 400 subjects were considered capable of responding to any type of hearing test, and that the mental ages of the subjects selected and those originally screened would place them in the lower echelons of the retarded population. Non-auditory variables certainly accounted in a large measure for the failure to respond to tones of low intensity rather than lessened auditory acuity.

The effect of repeated testing and training on the reduction of incidence of loss has been illustrated. What of the use of other tests which might be more satisfactory in establishing the incidence of loss in such a population? Speech audiometry (SRT Test), which was first used at the time of the initial battery of hearing tests was administered, was failed by a 30 db or greater criterion by 11 subjects and by 10 subjects in the final testing session. If we were to stretch a point and consider speech and pure tone testing as measuring the same functional pattern, the incidence of loss would have dropped to 5 per cent. With a 20 db or greater criterion, the incidence of loss would have been 9 per cent, as 18 subjects failed this criterion. In addition to repeated testing, and the criteria established, this type of test appears to reduce the amount of incidence of hearing loss. Interestingly enough, GSR audiometry also had only 10 subjects failing at a 30 db average. However, 14 subjects could not be tested so that the incidence of loss would be higher if they were included as having losses at that level.

The effects of listening training and its promise for lowered thresholds were investigated and evaluated from the viewpoint of a change in magnitude of scores, direction of threshold, intelligence and behavioral changes in communication attitude as rated by instructors in the listening program. So far as the effect of the program upon auditory thresholds is concerned, observable but not statistically significant changes were noted in all of the tests with the exception of GSR audiometry in which a significantly lowered threshold from first to final interval was found. The direction of change was significantly positive in all tests but the Speech Reception Threshold test where it was surmised that valid thresholds were attained in initial testing. Besides slightly improved thresholds in terms of magnitude and significantly improved thresholds in terms of change in a positive direction, thresholds on the whole were also maintained and did not regress.

Intelligence testing, using the short form of the Stanford-Binet and the Peabody Picture Vocabulary Test, showed observable and greater than anticipated changes in magnitude. These changes, however, were not significant. In terms of positive direction of change these were significant. Communication interaction also demonstrated changes in a positive direction. Any modification in behavior, intelligence testing or thresholds of hearing will be limited by factors outside the instructions, examinee and instructor relationship, methods of testing, and amount of testing. There are organismic factors, previously stated, such as ear pathology, neural pathology and psychic factors operant in an experimental group such as this which set upper limits on hearing, intelligence and other responses, and arouse suspicion concerning the reliability and validity of such responses.

If it were possible to use one test only to obtain hearing thresholds, or answer the question of the approximate amount of usable hearing a retarded child has, the results of this investigation point out that that test would be an auditory test based on speech. The SRT test of this experiment demonstrated consistently lower threshold responses than the other tests, a reliability of response superior to the various pure tone tests given and a comprehensive grasp of the method which enabled all but one of the subjects to respond adequately to the stimuli. On the other hand, the GSR audiometry technique would be recommended only as a last resort. Its requirements in terms of personnel, equipment and examinee responsiveness limit its usefulness. In addition, this test is not successful when other hearing test methods fail. A further handicap in its use so far as retarded children are concerned is that it is not a reliable test. The change in thresholds from first to final test intervals observed in this investigation is indicative of the unreliability of this method of response. Empirical observations are in accord with the results. The time involved, the extaneous movements, distractibility, fatigue and other behaviors not conductive to conditioning for threshold measurements of hearing via GSR audiometry militated against this test technique.

If a battery of tests were to be used in testing the auditory ability of mentally retarded subjects, in addition to the SRT test, any of the pure tone air conduction tests would be adequate. These varied only in terms of response. Probably a trial using ear-choice, standard or play audiometry would suggest the method of response to be used.

In addition to test findings as indicators of the effectiveness of a listening program, observations of test-taking and listening behavior offer clues as to the hearing abilities of these subjects. Subjective description of participant behavior in conditioning games, hearing localization practice and progressive lessons in developmental auditory practice which seem to improve such factors as attention and understandability, are invaluable adjuncts to a test program. Not understanding what is required of him in terms of stimulus-response patterns, leaves the subjects no choice but to respond to sound stimuli of high intensity, not respond at all, react when urged or respond when he feels like it. To overcome this attitude and negate some of the behavioral and physiological factors which inhibit responses to auditory stimuli it is recommended that the following course be followed in testing the hearing of mental retardates:

1. Hearing testing be repeated at selected intervals.
2. A battery of tests be administered, one of which will be a speech audiometric test and the other a pure tone, subjective-type test. In addition, a bone conduction pure tone test might be included to determine the type of loss, if any.
3. A short term of auditory or listening training preceding examinations would aid in obtaining threshold or close to threshold results by:
    a. permitting the subject to become acquainted with the examiner and the examiner with the child, thereby eliminating a possible deterrent to testing, i.e. poor interpersonal interaction.

b. enabling the subject's attention to be directed to sound through training at high intensity levels thus establishing a "set" or anticipation of the stimulus.
c. improving responsiveness to activities involving intelligence testing and thus permit a truer measure of the subject's capacities.
d. allowing the examiner to gather information about the subject which would be of value to other disciplines in diagnosis and programming.

Difficulties in testing young children who may or may not be retarded, as noted in the literature and clinical experiences of the author with young children who cannot or will not respond to hearing testing, could be ameliorated by following somewhat the same procedures suggested above. A training program especially geared to condition a child to hearing testing may motivate improved stimulus-response patterns. The development of a speech audiometric test for children utilizing picture and word stimuli would seem on the basis of this investigation to be a worthwhile follow-up. Validation and reliability studies would have to be accomplished on large populations at various developmental levels. If it improves diagnostic procedures with the retarded, the disturbed and the crippled child, its value would be unquestioned.

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Appendix 1

Speech Reception Threshold Technical Procedures

A tape recording was made using as stimuli twelve spondees based on pictures taken from the Bryngleson-Glaspey (18) speech set. These included the following words:

1. Bird Nest
2. Airplane
3. Toothbrush
4. Bathtub
5. Fishbowl
6. Football
7. Brown Bear
8. Fire Truck
9. Bull Frog
10. Steamship
11. Mailbox
12. Jackknife

Four pictures, as grouped above, were placed on each of three panels. Pictures 1 to 4 were on panel one, 5 to 8 on the second panel, and 9 to 12 were on panel three.

In preparing the tape, a calibration tone of 2,000 cycles per second fed by a Beltone Audiometer, Model 15A, was used. The same level was maintained in recording the spondees on a Revere Tape Recorder, Model T202, through a Grason-Stadler Audiometer. The words were recorded at five-second intervals. The reader watched the VU Meter of the speech audiometer and after several trials was able to maintain vocal intensity at a level during which the needle deflection did not peak beyond zero level on the meter. The recording speed was 7 1/2 inches per second.

In the testing procedure a Wollensak Tape Recorder was used in which the output was connected to a Beltone Audiometer "tape hi" input. The Wollensak volume control was set at 6 and the tone control at balanced tone. Before each test the calibration tone on the tape was used and the audiometer adjusted to the correct setting by means of the gain control of the Beltone Audiometer. This setting was obtained on normal college students before presenting the test to the retarded subjects. The test was calibrated using the 28 best ears of these college students whose hearing was normal. Pure tone air conduction testing was done on their better ear. The speech frequency average of the 28 students using frequencies 500 to 4,000

cps was -6 with a range of 0 to -10. The average speech reception threshold, based on the pictured spondees, and utilizing the calibration procedures outlined above, was found to be -4.6 db with a range from 0 to -10. Therefore, -5 was arbitrarily selected as the normal threshold of understandability for this type of testing. The thresholds of understandability and detectability are not precisely the same, so it was understood that the speech intensity was roughly 10 db greater than the pure tone stimuli. Spondee list W-1, played through a Grason-Stadler speech audiometer, confirmed this, with the college students obtaining a group average threshold hearing level for speech of 2 db ranging -2 to 10 db.

Appendix 2

Listening Program Procedures

Lesson	Objective(s)	Description of methods and materials
1	1. To acquaint subjects with play audiometry test situation a. by exposing subjects to test stimuli b. by giving subjects idea of responding to stimuli c. by relating test stimuli and responses of subject	1. Subjects spent ten minutes listening in a free field to a 1000 cps tone of 95 db intensity, responding when they heard by striking an inflated clown 2. Under earphones, they listened to the same tone at an intensity of 80 db which alternated between two subjects. Upon hearing the tone at irregular intervals, each subject made a crayon mark on a piece of paper.
2	Same as Lesson 1	1. Same as Lesson 1 except that subject's response consisted of dropping different shaped blocks into matching holes in the roof of a playhouse and hitting a pegboard with a hammer.
3	1. To acquaint subjects with variation in test stimuli a. by exposing subjects to different intensity levels b. by teaching recognition of different intensity levels c. by teaching different responses to varying intensity levels	1. Reviewed first part of above in groups of three. 2. Demonstrated soft and loud tones as each subject heard a 95 db tone of 1000 cps under earphones and at 60 db. Adjustments in intensity were made for subjects who could not hear lower intensity or had difficulty in detecting 35 db difference. The response consisted of standing on loud tones and sitting on soft tones. 3. Shook a group of bells to loud tones and dusted a table with a duster on soft tones. 4. Blew a whistle on loud tones and gestured a "quiet" symbol on soft.

Lesson	Objective(s)	Description of methods and materials
4	Same as Lesson 3	1. Reviewed Lesson 2 – hitting peg board with hammer, and Lesson 3 (2) and (4). 2. The subjects hit a peg board for loud sounds and rocked a doll in their arms for the soft sound.
5	1. To acquaint subjects with variations in test stimuli a. by exposing subjects to different pitch levels b. by teaching recognation of different responses to different pitch levels	1. Reviewed past exercises responding to a 1000 cps tone at 95 db and 60 db. 2. Differences in high and low pitch were explained. At a high pitch (2000 cps) under phones, subjects picked up a wooden model of a woman and at a low pitch (500 cps) a little girl. 3. Made a (sh) sound for low pitch and rang a gong for high pitch. 4. Shook bells for high pitch and used soft dust mop for low pitch.
6	Same as Lesson 5	1. Same as in Lesson 5 except for variation in responses as to representation of high and low pitches. 2. Attending to a low pitch, the subjects broke a balloon when it changed to a high pitch.
7	1. To acquaint subjects with gross environmental sounds a. by teaching subjects to attend to environmental sounds. b. by teaching subjects to respond to environmental sounds	1. Listening in groups of six, the subjects heard (free field) tape recorded environmental sounds. These included jingling of bells, noise made by squeezing a large toy frog. banging together of two pieces of wood, firing a toy gun and telephone dialing. Each sound was also demonstated live. The subjects selected objects before them, reproducing sound heard.

Lesson	Objective(s)	Description of methods and materials
7(cont')	c. by relating sound to motor act reproducing the sound	
8	Same as Lesson 7	1. Each subject was given one of the sound-producing sources used in Lesson 7. As the tape recording was played and he heard his sound he imitated it with his object. 2. With the objects on a table before them, each subject reproduced the sound heard while the other children indicated whether sound was correct. If it were not, the other subjects gave a correct response.
9	Same as Lessons 7 and 8	1. Reviewed two previous lessons. Each subject duplicated the sound heard. If in error, he continued to respond until correct. 2. Introduced new musical stimuli produced by musical toys, such as toy piano, cymbals, drum, et al. Instructors demonstrated sounds and then, listening to sounds on tape, the subjects selected object producing sound and duplicated taped sound.
10	Same as Lessons 7, 8 and 9	1. Continued general format of Lesson 9. Each Subject was assigned an instrument and duplicated his instrument's sound when heard on tape. Instruments were placed in the center of the group and each subject in turn identified and reproduced taped sound.
11	Same as Lessons 7,	1. Taped animal sounds of a rooster,

Lesson	Objective(s)	Description of methods and materials
11 (cont')	8, 9 and 10.	1. mouse, cow, horse, cat, and dog were employed. The subjects responded to toy representations of the sound as in Lessons 7, 8, 9, and 10.
12	Same as Lessons 7, 8, 9, 10 and 11.	1. Six subjects responded as a group to sounds matching by pointing to pictures of the animals they heard. 2. Individual responses were also secured.
13	1. To teach subjects sound localization a. by encouraging attentiveness to sound coming from two separate directions b. by teaching recognition of direction of sound source c. by relating direction of sound source to simple motor task.	1. Subjects were seated in the center of a large room with an instructor as a member of the group motivating correct responses. Two other instructors on opposite sides of the group, each with a tape recorder and duplicate tapes, presented a predetermined sequence of sounds. The response of the subjects was to point in the direction of the sounds and squeeze the proper rubber animals in the direction from which the sound emanated.
14	Same as Lesson 13	1. Reviewed Lesson 13, with subjects carrying rubber animals to sound source. 2. Live, rather than recorded stimuli were used, and the subjects pointed as a group in the direction of the various animal sounds.

Lesson	Objective(s)	Description of methods and materials
15	Same as Lesson 14	1. Repeated #2 above with subjects as a group pointing in direction of sounds employed in Lessons 7 and 9. 2. Followed verbal commands given by an instructor using two microphones connected to sound source on opposite sides of room. Commands were used, such as "Everyone stand up!", "Touch your ear!", "Point your [illegible] foot!", "John (or Mary) sit down!", and "Jump up and down!"
16	Same as Lessons 13 14 and 15	1. Group activity of Lesson 13 repeated. 2. Match sound of recording and object. 3. Localization with two subjects replacing instructors on either side of the room. The remaining subjects named the person who made the animal sound.
17	1. To reinforce previous training in attending a. by giving a motor response to sounds of different frequency levels b. by localizing sound sources	1. Using music toys, a localization exercise was given. 2. Differences in pitch were explained as a high and low tone. Presented through earphones, high pitch (2000 cps at 80 db) was associated with a large rubber ball, low pitch (500 cps at 80 db) by a small ball. 3. Practiced a sweep check, 250 to 8000 cps, at 60 db with subject signalling hearing by picking up what he considered the right ball.
18	Same as Lesson 17	1. In groups of three, subjects reviewed Lesson 7, pointing to direction of sound. 2. A sweep check with audiometer was given at 60 db. Each subject saluted when he heard a tone. This was given to one ear only with subject holding earphone against his ear.

Lesson	Objective(s)	Description of methods and materials
18 (cont')		3. The difference between loud (95 db at 1000 cps) and soft (60 db at 1000 cps) was reviewed using a hammer and peg board for the former and a "quiet" gesture for the latter. 4. Reviewed high (2000 cps at 80 db) and low (500 cps at 80 db) pitch as subjects responded with raised hands for the former and pointing to the table at which they sat for the latter.
19	Same as Lessons 13, 14, 15 and 16.	1. A group was placed in the center of room with instructors on either side randomly producing animal sounds. The group pointed in the direction of the sound. 2. Subjects called by name, walked toward the direction of the call. 3. Subjects named animal sounds produced by the instructor. 4. Individual 60 db sweep checks given to one ear and a selected animal was squeezed when the subject heard sound.
20	Same as Lessons 13, 14, 15, 16 and 19.	1. Subjects were re-familiarized with toy music instrument sounds. Closing their eyes, they were then asked to name sound heard. 2. Each produced a specific sound when asked and other members of group pointed to sound source. 3. Response to 60 db sweep with sound object.
21	1. To teach memory for rhythms a. by letting subjects hear simple rhythm patterns	1. Subjects listened to rhythm on toy drum, and were asked to produce it. 2. Instructor and subject produced rhythm together. 3. Rhythm band instruments used to produce rhythm.

Lesson	Objective(s)	Description of methods and materials
21 (cont')	b. by encouraging subjects to reproduce these rhythm patterns.	
22	Same as Lesson 21 and in addition to teach familiarization to music as stimuli	1. Using a Warren Auditory Training Unit (Model W-2-S), subjects pointed to earphone in which record was heard. Music of "The Big Bass Drum" was alternated from one ear to another. 2. Record played through loud speaker and all, accompanying instructor, beat rhythm. 3. Individual listening was done to "The Children's Marching Song" and subject clapped hands in rhythm. The sound was switched from ear to ear. 4. Repeated #2 above.
23	1. To teach response to speech stimuli a. by encouraging subjects to listen to verbal commands b. by practicing immediate recall and following verbal commands	1. Review Lesson 21. 2. Subject performed simple tasks in response to verbal commands varying according to abilities of subjects. With objects before them, subjects were given commands such as: a. shake the bells - hit the blocks together. b. clap your hands - bounce the ball c. shoot the gun - ring the phone - stand up 3. Formed circle and followed verbal commands as a group and as individuals when name was called.
24	Same as Lesson 23, also to review and give sweep frequency check.	1. Subjects listened to a music recording through earphones and indicated in which ear the music was heard. 2. One ear sweep frequency check at 60 db

Lesson	Objective(s)	Description of methods and materials
24 (cont')		was given. 3. A Bell Telephone Educational Training Unit was used. An instructor outside the room phoned and a subject answered. He was given instructions over the phone concerning what was to be done with various toys on the table before him. Verbal command examples were: Pick up the bells, put the chair under the table, pick up the doll baby, rock her and then put her back on the table.
25	Same as Lessons 23 and 24. (give the subjects opportunity to listen to music through earphones for a fifteen minute period before formal lesson began)	1. Preceding this regular lesson and all the following, subjects were given fifteen minutes of listening to music via earphones. A Grason-Stadler Group Hearing Aid, Model 260 BP, was used. No response was required to children's records. 2. Sweep frequency check of 50 db for each subject who responded with a salute. 3. A "See and Say" game was used in which instructor held up card identical to those held by different subjects. In response to questions "Who has the picture of ____?" subjects were encouraged to respond by saying "I do," or naming the picture. 4. Subjects were trained in recognizing pictures of the SRT test used in the study. The picture was named through the Warren Auditory Training Unit and the subject pointed to the picture whose name he heard through the earphones.
26	Same as Lessons 23, 24 and 25.	1. Using the Bell Telephone Educational Unit, verbal commands were reviewed by the instructors. Further commands were added which requested repetition of a social phase. 2. A sweep frequency check at 50 db was given

Lesson	Objective(s)	Description of methods and materials
26 (cont')		to each subject who was required to respond by raising his hand.
27	1. To review and reinforce previous training	1. Reviewed various activities, including (a) See and Say game, (b) responding to sounds of toy musical instruments heard on tape by pointing to object, (c) listening to loud sounds (95 db, 1000 cps) and soft sounds (60 db, 1000 cps) and replying with appropriate action with selected objects, and (d) following simple verbal commands which were made progressively more difficult.
28	Same as Lesson 27.	1. Review covering (a) 50 db sweep check, hitting peg board in response to sound, (b) responding to high and low pitches, (c) following commands via the Bell Telephone Educational Unit, and (d) matching picture of animal with corresponding sound.
29	Same as Lessons 27 and 28	1. Listening for tones from the audiometer, the subjects punched an inflated clown when tone was heard. 2. Two children each held an earphone to an ear. The child who heard a sound raised his hand. 3. Localized sound sources. 4. Play audiometry used with 50 db sweep check.
30	Same as Lesson 27, 28 and 29	1. Using Warren Auditory Training Unit, subjects responded to SRT words by pointing to picture spoken through the microphone by an instructor. 2. Commands given through the unit. 3. Clapped hands to "Children's Marching Song" with unit volume up.

Lesson	Objective(s)	Description of methods and materials
30 (cont')		4. Using binaural controls, music was alternated from one ear to another. Subjects pointed to the ear in which sound was heard.

Appendix 3

Table 25

Average Audiometric Thresholds of Mental Retardates at Three Spaced Intervals Utilizing Six Varied Hearing Tests.*

					Tests			
Subjects	Interval	Ear	Play	Ear-Choice	Standard	BC	GSR**	SRT
A1	1	R	36	34	24	35	15	15
		L	30	25	20	29	28	10
	2	R	28	29	30	23		10
		L	19	18	23	28		5
	3	R	19	23	19	15	20	5
		L	16	19	14	18	18	5
A2	1	R	6	-1	9	-9	CNT[1]	0
		L	6	5	13	-4	CNT	0
	2	R	13	16	15	15		5
		L	11	18	10	16		5
	3	R	6	8	8	11	CNT	5
		L	6	8	9	11	CNT	5
A3	1	R	48	43	41	14	33	35
		L	46	44	39	9	48	35
	2	R	40	43	21	11		35
		L	39	40	16	18		30
	3	R	46	44	55	18	30	40
		L	24	25	25	20	33	15
A4	1	R	33	30	30	20	38	10
		L	21	19	19	21	30	5
	2	R	33	24	26	9		20
		L	24	19	10	16		10
	3	R	29	34	40	26	25	20
		L	11	14	19	20	10	15
A5	1	R	34	46	CNT	CNT	CNT	30
		L	16	49	CNT	CNT	CNT	15
	2	R	06	10	8	13		0
		L	19	13	9	14		0
	3	R	09	8	16	19	3	0
		L	10	10	13	24	8	5

TABLE (continued)

					Tests			
Subjects	Interval	Ear	Play	Ear-Choice	Standard	BC	GSR**	SRT
A6	1	R	19	28	36	26	28	5
		L	25	31	31	23	28	5
	2	R	16	21	15	CNT		-5
		L	18	21	10	CNT		0
	3	R	21	23	15	24	25	5
		L	21	24	10	28	33	5
A7	1	R	23	23	24	26	10	10
		L	48	43	54	31	28	10
	2	R	40	45	40	50		5
		L	40	35	24	15		15
	3	R	43	41	29	26	15	20
		L	21	23	29	29	0	5
A8	1	R	23	21	19	18	15	15
		L	18	21	19	18	18	5
	2	R	16	20	19	10		10
		L	19	15	9	10		10
	3	R	18	18	21	13	10	10
		L	11	14	19	19	5	10
A9	1	R	23	25	23	28	13	0
		L	21	21	18	31	18	0
	2	R	19	18	20	26		5
		L	18	14	31	16		0
	3	R	26	24	18	11	15	15
		L	19	16	18	18	5	5
A10	1	R	15	9	18	28	35	5
		L	14	14	16	31	35	5
	2	R	CNT	14	CNT	CNT		10
		L	CNT	18	CNT	CNT		5
	3	R	15	18	CNT	CNT	CNT	-5
		L	10	18	CNT	CNT	CNT	10
A11	1	R	50	68	43	31	23	30
		L	64	65	55	39	23	35

TABLE(continued)

Subjects	Interval	Ear	Play	Ear-Choice	Tests		GSR**	SRT
					Standard	BC		
A11 (continued)	2	R	41	41	34	20		30
		L	45	44	39	25		20
	3	R	31	31	15	24	53	10
		L	48	48	25	20	50	25
A12	1	R	14	11	-5	19	CNT	5
		L	10	11	3	26	CNT	0
	2	R	21	26	25	29		10
		L	24	19	24	24		0
	3	R	14	14	18	15	0	0
		L	13	13	14	14	0	0
A13	1	R	34	36	38	25	CNT	20
		L	25	26	33	29	CNT	10
	2	R	56	59	68	0		35
		L	26	23	19	6		10
	3	R	18	16	24	14	28	5
		L	13	14	23	18	10	5
A14	1	R	CNT	CNT	CNT	CNT	23	15
		L	CNT	CNT	CNT	CNT	30	15
	2	R	21	20	28	16		10
		L	11	16	15	14		0
	3	R	20	18	24	20	15	10
		L	15	15	25	23	10	10
A15	1	R	18	20	14	11	28	0
		L	21	20	19	10	20	15
	2	R	21	20	14	5		5
		L	21	24	16	8		5
	3	R	10	8	10	11	CNT	0
		L	6	6	15	10	CNT	10
A16	1	R	19	23	24	25	23	10
		L	19	18	18	21	110	0
	2	R	16	15	18	9		5
		L	10	9	11	10		0

TABLE (continued)

					Tests			
Subjects	Interval	Ear	Play	Ear-Choice	Standard	BC	GSR**	SRT
A16 (continued)	3	R	18	16	14	21	15	5
		L	10	9	10	11	8	5
A17	1	R	18	18	13	35	23	0
		L	19	18	18	35	18	0
	2	R	14	15	13	10		5
		L	15	19	13	14		5
	3	R	14	14	10	19	20	5
		L	16	16	13	21	18	5
A18	1	R	13	11	20	38	5	20
		L	11	14	14	43	3	15
	2	R	18	15	16	21		5
		L	24	21	21	15		0
	3	R	39	36	8	16	-3	0
		L	39	33	15	16	-3	-5
A19	1	R	8	8	18	18	23	15
		L	13	10	14	19	10	10
	2	R	33	30	35	8		20
		L	24	29	39	9		15
	3	R	18	18	19	13	13	5
		L	21	18	23	10	20	15
A20	1	R	30	26	13	5	20	10
		L	23	20	14	4	25	0
	2	R	16	21	23	18		15
		L	16	20	23	19		15
	3	R	13	18	18	18	13	10
		L	11	18	18	18	18	5
A21	1	R	38	CNT	CNT	CNT	CNT	25
		L	34	CNT	CNT	CNT	CNT	35
	2	R	13	20	23	26		30
		L	25	30	28	21		25
	3	R	18	21	35	31	CNT	35
		L	18	21	38	28	CNT	20

TABLE (continued)

					Tests			
Subjects	Interval	Ear	Play	Ear-Choice	Standard	BC	GSR**	SRT
A22	1	R	23	21	19	20	CNT	5
		L	24	23	20	18	CNT	5
	2	R	13	14	23	16		0
		L	11	14	23	18		0
	3	R						
		L	not available					
A23	1	R	30	30	34	25	48	30
		L	39	39	55	21	53	40
	2	R	29	34	31	15		20
		L	43	41	41	23		30
	3	R	29	38	33	20	50	20
		L	41	41	39	20	53	30
A24	1	R	CNT	10	20	25	10	CNT
		L	CNT	10	18	23	18	CNT
	2	R	CNT	CNT	CNT	CNT	CNT	10
		L	CNT	CNT	CNT	CNT	CNT	5
	3	R	24	28	19	18	CNT	10
		L	28	29	19	24	CNT	15
A25	1	R	26	71	68	48	73	40
		L	44	68	70	56	100	40
	2	R	19	18	14	19		25
		L	21	19	11	23		25
	3	R	46	49	16	23	48	25
		L	59	55	16	15	80	20
A26	1	R	34	34	20	15	15	15
		L	14	13	14	19	13	5
	2	R	23	21	16	20		10
		L	21	19	21	18		0
	3	R	9	8	30	15	15	20
		L	14	10	18	13	10	10
A27	1	R	40	40	58	14	33	20
		L	29	33	63	20	20	0

TABLE (continued)

Subjects	Interval	Ear	Play	Ear-Choice	Tests		GSR**	SRT
					Standard	BC		
A27 (continued)	2	R	19	10	33	45		5
		L	13	10	41	39		0
	3	R	30	34	18	13	18	20
		L	5	9	16	28	8	5
A28	1	R	18	20	14	-3	40	5
		L	19	14	14	23	CNT	0
	2	R	-5	-5	9	20		0
		L	-2	1	8	20		-5
	3	R	16	6	0	5	8	0
		L	11	5	4	13	18	-10
A29	1	R	46	43	40	15	CNT	15
		L	36	38	29	18	CNT	20
	2	R	50	48	48	1		35
		L	28	33	29	10		15
	3	R	20	21	39	18	CNT	35
		L	21	19	30	18	CNT	20
A30	1	R	28	29	35	11	45	25
		L	14	16	15	15	55	10
	2	R	10	14	14	15		0
		L	13	14	10	13		5
	3	R	9	10	18	18	8	0
		L	10	10	18	26	3	0
A31	1	R	23	25	26	36	33	5
		L	23	21	25	38	35	5
	2	R	9	13	5	11		0
		L	8	9	14	20		0
	3	R	9	9	18	16	0	5
		L	13	11	16	18	18	0
A32	1	R	85	83	80	CNT	88	100
		L	91	94	94	CNT	95	100
	2	R	80	81	75	CNT		90
		L	89	89	73	CNT		70

TABLE (continued).

Subjects	Interval	Ear	Play	Ear-Choice	Tests		GSR**	SRT
					Standard	PC		
A32 (continued)	3	R	76	76	75	CNT		100
		L	89	88	86	CNT		100
A33	1	R	71	78	75	36	80	40
		L	38	43	39	36	38	15
	2	R	64	60	55	35		35
		L	65	58	42	33		30
	3	R	44	66	35	34	CNT	55
		L	33	35	36	26	CNT	25
A34	1	R	25	13	16	18	40	-5
		L	28	18	15	24	CNT	5
	2	R	9	8	6	16		0
		L	13	9	5	11		0
	3	R	14	8	13	15	-3	0
		L	14	16	4	15	5	0
A35	1	R	26	31	20	15	25	0
		L	34	31	25	18	30	15
	2	R	18	15	15	23		15
		L	20	19	18	24		15
	3	R	16	24	20	18	28	15
		L	26	24	18	20	33	15
A36	1	R	16	19	18	20	25	0
		L	13	19	14	16	18	0
	2	R	15	11	11	10		5
		L	6	8	4	8		0
	3	R	13	14	14	9	0	5
		L	4	4	9	6	13	0
A37	1	R	CNT	CNT	CNT	CNT	CNT	10
		L	CNT	CNT	CNT	CNT	CNT	0
	2	R	CNT	CNT	CNT	CNT		10
		L	CNT	CNT	CNT	CNT		10
	3	R	CNT	CNT	CNT	CNT	CNT	15
		L	CNT	CNT	CNT	CNT	CNT	10

TABLE (continued)

					Tests			
Subjects	Interval	Ear	Play	Ear-Choice	Standard	BC	GSR**	SRT
A38	1	R	16	14	16	13	15	-5
		L	43	39	45	15	40	5
	2	R	5	5	8	11		0
		L	4	4	14	14		10
	3	R	-1	1	11	23	-8	0
		L	8	6	13	19	15	0
A39	1	R	16	19	16	26	40	0
		L	26	21	13	28	40	10
	2	R	0	16	13	8		0
		L	4	13	18	13		0
	3	R	8	11	21	19	15	0
		L	8	8	21	19	18	0
A40	1	R	26	24	33	13	25	0
		L	24	24	25	20	25	5
	2	R	8	21	11	23		5
		L	15	15	28	13		5
	3	R	14	15	21	30	8	5
		L	23	18	29	26	CNT	5
A41	1	R	16	16	20	21	CNT	20
		L	24	24	23	20	CNT	25
	2	R	24	25	-2	0		20
		L	23	21	-5	0		20
	3	R	11	13	20	16	13	15
		L	13	8	19	23	CNT	15
A42	1	R	44	CNT	35	24	43	35
		L	40	CNT	38	28	50	30
	2	R	26	25	31	10		20
		L	40	43	28	18		40
	3	R	16	14	25	10	CNT	20
		L	15	21	29	8	CNT	30
A43	1	R	16	18	41	20	28	0
		L	19	18	38	31	20	-5

TABLE (continued)

Subjects	Interval	Ear	Play	Ear-Choice	Tests			
					Standard	BC	GSR**	SRT
A43 (continued)	2	R	18	11	20	10		10
		L	9	14	9	11	8	5
	3	R	13	14	15	15	13	15
		L	13	9	4	11	8	5

TABLE

Subjects	Interval	Ear	Play	Ear-Choice	Tests			
					Standard	BC	GSR	SRT
B1	1	R	19	14	CNT	CNT	30	5
		L	18	14	CNT	CNT	40	10
	2	R	29	28	25	29		20
		L	25	26	18	19		10
	3	R	18	11	11	11	20	5
		L	18	14	14	13	30	10
B2	1	R	CNT	CNT	CNT	CNT	CNT	CNT
		L	CNT	CNT	CNT	CNT	CNT	CNT
	2	R	CNT	CNT	51	CNT		25
		L	CNT	CNT	30	CNT		20
	3	R	CNT	35	CNT	CNT	CNT	25
		L	CNT	20	CNT	CNT	CNT	25
B3	1	R	CNT	CNT	CNT	CNT	35	25
		L	CNT	CNT	CNT	CNT	70	20
	2	R	41	41	48	26		40
		L	35	35	26	28		15
	3	R	45	50	48	26	48	20
		L	34	34	30	25	50	15

TABLE

			Tests					
Subjects	Interval	Ear	Play	Ear-Choice	Standard	BC	GSR	SRT
B4	1	R	14	11	14	10	CNT	5
		L	10	8	9	9	CNT	0
	2	R	13	20	25	14		5
		L	9	14	16	21		5
	3	R	5	8	11	-3	25	5
		L	8	10	9	0	33	5
B5	1	R	14	14	5	1	18	0
		L	19	14	18	1	25	5
	2	R	10	8	5	9		5
		L	9	15	5	13		0
	3	R	3	4	3	-1	0	5
		L	6	4	6	3	5	0
B6	1	R	CNT	CNT	CNT	CNT	CNT	CNT
		L	CNT	CNT	CNT	CNT	CNT	CNT
	2	R	30	CNT	CNT	CNT		30
		L	39	CNT	CNT	CNT		40
	3	R	26	CNT	CNT	CNT	CNT	25
		L	28	CNT	CNT	CNT	CNT	45
B7	1	R	CNT	CNT	CNT	CNT	CNT	CNT
		L	CNT	CNT	CNT	CNT	CNT	CNT
	2	R	CNT	34	48	CNT		25
		L	CNT	35	CNT	CNT		30
	3	R	31	30	28	30	CNT	20
		L	43	43	33	28	CNT	15
B8	1	R	49	40	61	59	CNT	CNT
		L	43	43	63	59	CNT	CNT
	2	R	94	95	93	CNT		70
		L	91	93	85	CNT		70
	3	R	85	88	83	CNT	CNT	65
		L	79	78	71	CNT	CNT	50
B9	1	R	10	9	5	0	CNT	0
		L	15	8	d	0	CNT	5

TABLE (continued)

Subjects	Interval	Ear	Play	Ear-Choice	Standard	BC	GSR	SRT
B9 (continued)	2	R	9	5	16	20		5
		L	8	8	15	19		5
	3	R			1	-4		5
		L			3	-4	28	10
B10	1	R	CNT	CNT	CNT	CNT	CNT	CNT
		L	CNT	CNT	CNT	CNT	CNT	CNT
	2	R	CNT	CNT	CNT	CNT	CNT	CNT
		L	CNT	CNT	CNT	CNT	CNT	CNT
	3	R	CNT	CNT	CNT	CNT	CNT	CNT
		L	CNT	CNT	CNT	CNT	CNT	CNT
N1	1	R	18	13	15	24	Not	Not
		L	29	15	20	24	Given	Given
	2	R	6	8	13	28	Not	0
		L	9	8	11	33	Given	0
N2	1	R	CNT	15	15	CNT	Not	15
		L	CNT	10	16	CNT	Given	15
	2	R	13	14	25	29	Not	10
		L	16	14	26	34	Given	10
N3	1	R	4	6	15	11	Not	10
		L	9	11	9	8	Given	5
	2	R	0	1	9	14	Not	10
		L	3	-4	-1	0	Given	10
N4	1	R	24	CNT	24	8	Not	15
		L	35	CNT	29	8	Given	25
	2	R	20	18	24	16	Not	10
		L	20	16	20	19	Given	10
N5	1	R	36	40	38	24	Not	30
		L	34	41	34	15	Given	30
	2	R	26	29	43	41	-8	25
		L	18	18	24	29	-8	35

TABLE (continued)

			Tests					
Subjects	Interval	Ear	Play	Ear-Choice	Standard	BC	GSR	SRT
01	1	R	20	15	19	28	18	Not
		L	23	24	21	24	23	Given
02	1	R	10	5	10	28	CNT	Not
		L	11	10	9	26	CNT	Given
03	1	R	21	23	19	26	20	5
		L	20	18	13	24	55	5
04	1	R	18	15	16	29	23	10
		L	49	48	56	30	45	50
05	1	R	CNT	CNT	CNT	CNT	13	60
		L	CNT	CNT	CNT	CNT	15	50
06	1	R	19	10	26	24		0
		L	14	10	20	23		10
07	1	R	6	14	10	0		5
		L	4	14	3	0		0

Appendix 4

TABLE 26

Ratings* of Communication Interaction at Beginning and End of Training Period for Each Institutionalized Subject

Subject Number	Before	After
A1	3	4
A2	3	3
A3	2	2
A4	3	3
A5	0	1
A6	2	1
A7	4	5
A8	3	2
A9	1	2
A10	1	0
A11	1	2
A12	3	3
A13	2	2
A14	1	2
A15	3	3
A16	3	4
A17	1	3
A18	2	1
A19	3	4
A20	1	2
A21	1	2
A22	4	5
A23	2	2
A24	1	1
A25	2	2
A26	3	3
A27	3	4
A28	3	4
A29	3	3
A30	4	4
A31	3	4
A32	1	1
A33	2	1
A34	3	3
A35	2	2
A36	4	4

TABLE (continued)

Appendix 4 (continued)

Subject Number	Before	After
A37	0	1
A38	2	3
A39	4	4
A40	3	4
A41	3	3
A42	1	2
A43	4	3

* Communication interaction ratings:

5. Excellent
4 Very Good
3 Good
2 Poor
1 None

5 4122 ③

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